PREDICTING MATERNAL BEHAVIOUR OF BEEF CATTLE USING TEMPERAMENT TESTS

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ABSTRACT

Certain temperament traits that exist may be accurate predictors of the behaviour animals will exhibit towards stockpersons and their offspring after parturition. A total of 184 beef cattle in year 1 and 169 in year 2 (99 of these were also tested in year 1) were run through a chute complex and individually restrained before calving to see if their response predicted their behaviour after calving. Pre-calving measurements included exertion force applied against the headgate, a subjective temperament score, the response to a stockperson standing in front of the headgate and the exit speed from the chute. Within 2 d after calving, the cow's response to her calf, stockpersons and a predator model were recorded during standardized testing. A blood sample from each calf was collected to measure total serum protein and the calf's adjusted 205 d weaning weight was recorded in year 1. A principal component analysis was used to reduce the number of variables. The components were then used to generate multiple regression trees. The results of this study indicated that many measures of maternal behaviour were not related to the temperament of the animal. The amount of time the cow spends greater than 3m from the calf when it is being handled was somewhat related to temperament; however, this variable may indicate fearfulness of people rather than maternal behaviour. It appears that a cow's temperament is, in general, a poor predictor of maternal behaviour. A producer survey was also conducted on 168 cattle producers at 3 Saskatchewan cattle events. The cumulative number of cows owned by the respondents was 33,621, 5.7% of which were reported to be dangerous (cows the producer judged would hurt them after calving if given the chance). The majority of farms (76.2%) had at least one dangerous cow. Mis-mothering (i.e. the cow abandoned or did not care for her calf) had an incidence of 1.4% of cows, and occurred on 56.3% farms. Producers are more tolerant of aggressive cows and are less likely to cull them than cows which abandon or mis-mother their calves.

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1 INTRODUCTION

Maternal behaviour is an important aspect of modern beef production. Proper maternal behaviour pre and postpartum leads to proper development of the mother-offspring bond, which is important in the calf's survival. Many factors can impact the maternal behaviour exhibited by a particular female such as breed, experience and hormone profile. Maternal behaviour of cattle has been assessed using primarily subjective scores; however, some attempts at using objective measurements have been made.

Cattle may be required to protect their offspring from predators to ensure their survival. This behaviour is, in some situations, shown towards humans as well. Maternal aggression results in human deaths and injuries every year. While this aggression may seem essential to protect the calf, it is likely that cattle can differentiate between humans and predators, and therefore aggression shown by cattle towards humans is not necessary.

Temperament is considered a stable and repeatable property of an animal, and therefore an animal's temperament may be related to its response to its offspring and to people handling its offspring. Research in swine has shown that stock-person related aggression as well as savaging of piglets is related to an individual gilt's temperament (Marchant Forde, 2002). If this is also true in cattle, a temperament test could be used in commercial settings to predict the maternal behaviour that a cow is likely to show.

While maternal aggression and mis-mothering are known to occur in commercial beef production, the incidence of these behaviours and tolerance that producers have for them is not known. It is also unknown if there are specific management practices or situations which cause cattle to mis-mother their calf or become aggressive towards humans.

1.1 Thesis Objectives

Maternal behaviour has been investigated in sheep (O'Connor et al., 1985; Dwyer and Lawrence, 2000), yet the research in cattle is fairly minimal and comparisons are based almost exclusively on subjective scores (Sandelin et al., 2005; Turner and Lawrence, 2007; Hoppe et al., 2008). Chapter 2 of this thesis entails a review of important literature related to maternal behaviour and temperament along with ways to measure both maternal behaviour and temperament. The review also looks at the relevance and potential relationship between temperament and maternal behaviour, as well as issues such as predation and personal safety that are involved with beef cattle production.

The principal goal of the research, to attempt to relate pre-calving temperament with behaviour after calving, is outlined in Chapter 3. The study looked at comparisons between different principal components derived from temperament tests and maternal behaviour measurements in order to determine the predictability of maternal behaviour. This study used objective as well as subjective measurements to quantify both maternal behaviour and temperament. Another objective of this thesis was to examine whether maternal behaviour towards a stockperson handling her calf is related to her behaviour when exposed to a potential predator. We also investigated the impact of maternal behaviour on the weaning weight of the calf and the transfer of immunoglobulins from the cow to calf through colostrum.

Along with the study described in Chapter 3, a survey was conducted of cattle producers at two cattle shows in Saskatchewan in 2009 and the Saskatchewan Beef and Forage Symposium in 2010. These results can be found in Chapter 4. The incidence of dangerous cattle and of cattle that mis-mother their calf was investigated, as was the tolerance that producers exhibit when considering these behaviours. Producers were also asked to identify differences in temperament of these animals as well as the reasons they consider important in the development of these behaviours. Producers were also asked if they had been ever been injured by a cow at calving and predation incidence was considered as well. Comparisons were made between certain groups to determine underlying factors.

2 LITERATURE REVIEW

2.1 Maternal Behaviour

Maternal behaviour, as defined by Poletto (2010) is the pattern of behaviours that are shown by the mother to her dependent offspring or young. As the evolutionary success of a species depends on the survival of the offspring, maternal behaviour is of utmost importance in many species, particularly mammals. In many domestic species such as cattle, the female is solely responsible for care of the offspring. The maternal behaviour of the dam has a considerable impact on the survival and success of the offspring. Maternal behaviour includes the establishment of the cow-calf bond, nursing the calf and attentiveness to the calf by the cow which includes protection of the calf from predators as well as environmental protection (Grandinson, 2005; Hoppe et al., 2008).

The level of maternal care pre or postpartum depends somewhat on the development of the young. Altricial young are naked, blind and entirely dependent on their parent(s) for maintenance of bodily functions and this development is in many cases associated with reduced prepartum investment, often in the form of a short gestation or incubation period (Deeming, 2010a). The majority of the parental investment in these species thus occurs after birth or hatching. Precocial young are fully mobile at, or very soon after, birth and are covered with fur or feathers, but are in many cases still dependent on their parents for food, thermoregulation and/or protection from predators (Deeming, 2010b). Cattle, being precocial, have a longer gestation and considerable investment in the offspring before it is born. Calves rely on their mothers significantly in the early stages of life for food and protection.

2.1.1 Prepartum and Postpartum Behaviour

Maternal behaviour is triggered with the onset of parturition; however, in some species certain behaviours such as nest building will occur in the days before giving birth. In the hours before parturition, the female usually seeks and selects a birth site. This site is often isolated from the group, helping to decrease the interference from other females and increase the ease of formation of the mother-offspring bond. Parturient animals are attracted to birth fluids and newborns, and stealing of offspring can occur if the animals are not allowed to separate themselves sufficiently (Gonyou and Stookey, 1987). The period of time spent at the birth-site varies with individuals and breeds within a species (Chenoweth and Landaeta-Hernandez, 1998). The time that the mother spends at the birth site is important in establishing the mother-offspring bond (Nowak, 1996; Grandinson, 2005). Offspring are more likely to get separated from the dam if they spend less time at the birth site, and ewes, for example, are also more likely to abandon their offspring if they are moved from the birth site early on (Putu et al, 1988). It has been suggested that the first six hours following parturition are exceedingly important in sheep, and ewes that remain at the birth site for this period exhibit excellent maternal care and the lambs' chance of survival is improved (Nowak, 1996). A similar period is likely important in cattle, however as cattle generally have single offspring whereas sheep often give birth to multiple offspring, a shorter period could be sufficient.

In species such as cattle, parturient females will become restless immediately before parturition, possibly because of discomfort (von Keyserlingk and Weary, 2007). After a difficult birth, cows may be reluctant to stand, as has been found by Edwards and Broom (1982) for first parity cows, but this may be at least in part due to management practices in this study that involved putting the calf in front of the cow following assisted deliveries. This practice reduces the cow's desire and need to rise because she can reach the calf.

Behaviours which are present after parturition include licking, grooming, nursing, manipulation of offspring, and placentophagia. Many animals such as carnivores, rodents and ungulates (including cattle) perform placentophagia (the consumption of the placenta immediately after giving birth), which is thought to be important in uterine involution and recovery and facilitation of milk letdown through hormones that are present in the placenta (Poletto, 2010). Other possible explanations for placentophagia could be to improve cleanliness of the nest site or reduce the attraction of predators. The ingestion of amniotic fluid has also been shown to have some analgesic properties and help relieve pain after calving which may improve a cow's ability to care for her newborn calf (Pinheiro Machado et al., 1997).

Licking of the offspring is an important characteristic of maternal behaviour in many species, including cattle. Lidfors (1994) suggests that the high intensity of licking soon after parturition stimulates the calf to become active. Licking of the offspring also helps to dry the coat to decrease heat loss and improve hygiene, which in turn reduces the risk of predation and infection. This licking by the cow draws the calf's attention to the mother and as such is involved in the development of the bond between the dam and her offspring, as well as recognition of the young (Grandinson, 2005; Broom and Fraser, 2007). The recognition of offspring is important so that the mother does not indiscriminately provide resources to all offspring, including those that are not her own (Gonyou and Stookey, 1987). In cattle, bonding occurs when the offspring is wet with birth fluids, and if they are isolated, there is little chance of the mother bonding to an offspring other than her own (Gonyou and Stookey, 1987).

Ungulates are classified as either "hiders", where the offspring stays isolated for long periods of time, such as swine, or "followers" where close and frequent contact is maintained between the mother and infant, such as sheep (Lent, 1974). Cattle, although often considered hiders, have been suggested to follow both the hiding and following techniques, becoming weak hiders when a more covered habitat allows, and weak followers when the habitat is open grassland (Lidfors and Jensen, 1994). The hiding phase is generally short if it does occur and the calf is usually brought into the herd within two to four days after parturition, with some calves becoming integrated into the herd very shortly after birth (Lidfors and Jensen, 1994). In some cases, calves have been observed to remain near the birth site for a much longer period, up to nine days in one case (Lidfors and Jensen, 1988). Cattle appear to exhibit some plasticity in their postpartum behaviours, and adapt to the conditions in which they are present.

2.1.2 Abnormal Maternal Behaviour

Abnormal maternal behaviour patterns are considered those behaviours that are detrimental to the survival of the offspring. These would include abandonment of the offspring, aggression towards the offspring, failure to groom the offspring, failure or delay in first suckling because the mother fails to stand or standstill, and any other behaviour that may jeopardise the bond between the mother and offspring (Alexander, 1988).

Inexperienced mothers tend to show temporary delays in expression of maternal care and also disrupt the neonate's access to the udder more often than experienced mothers (Nowak et al., 2000). Primiparous mothers, being inexperienced, have the tendency to move around. This can interrupt the teat-seeking behaviour of the young, and affect the offsprings' ability to acquire colostrum (Lidfors, 1994). Aggression directed at the offspring is much more frequent in primiparous cattle and they may butt and kick when the calf approaches the udder more often than multiparous cows (Edwards and Broom, 1982). Fear, dystocia and poor nutritional status of the mother can also impact her level of care of the offspring (Nowak et al., 2000). These situations decrease the level of interest the mother has towards the offspring, which leads to hyperreactivity of the mother and can lead to desertion of the birth site and poor or nonexistent bond formation with the young (Nowak et al., 2000). This can lead to separation of the mother and offspring, and, in many situations, death of the offspring.

2.2 Suckling

The time to first suckle is important in calves because of the significance of colostrum ingestion. Once the newborn calf has successfully stood on its own, it then must find the teats and begin suckling. Teat-seeking behaviour precedes suckling and consists of exploratory nuzzling of the cow or similar object (Broom and Fraser, 2007). Calves will lick and suck at any object they encounter during this phase and in most cases this behaviour is ended when a teat is found. In some cases calves fail to find the teat in the first attempt and occasionally in subsequent attempts as well (Broom and Fraser, 2007). Time to suckle varies with breed and udder structure of the dam. This is particularly a problem with dairy breeds, as breeding for high milk production has resulted in cows with large, pendulous udders and teats, which can make it more difficult for the calf to find the teat and suckle. On average beef calves suckle within 97.3 minutes following birth and by and large all beef calves suckle within the first 4 hours (Lidfors, 1994). Calves generally suckle five to ten times each day when they are young and suckling bouts last approximately ten minutes (Broom and Fraser, 2007).

2.2.1 Colostrum

When neonates are born they leave the sterile environment of the uterus and become exposed to the microorganism loaded outside environment. Neonates are able to mount an immune response, but they are immunonaive and agammaglobulinemic, meaning that their protective mechanisms are immature and have not been exposed to antigens and so their immune response will be somewhat delayed (Barrington and Parish, 2001; Dewell et al., 2006). Because this response lags in time and concentration of immunoglobulins, it is important that maternal immunoglobulins are supplied to ensure that the neonate can respond to and survive infections.

In many mammalian species the passage of maternal antibodies to the offspring can occur through the placenta as well as through the colostrum. The structure of the placenta of cattle is such that prepartum transfer is prevented, so calves must rely on suckling to obtain passive transfer of maternal immunity through immunoglobulins present in colostrum. These immunoglobulins are transported from the circulation of the cow and/or produced in the mammary tissue and accumulate there prior to parturition (Barrington and Parish, 2001).

Colostrum is ingested by the calf and then absorbed into the digestive tract and essentially provides the calf with protection against disease, energy and other factors important for growth and development. The absorption of colostrum in a neonate's gut is highly unspecific, and there appears to be no differentiation in absorption between molecules such as immunoglobulins, lymphocytes, neutrophils, macrophages and epithelial cells (Barrington and Parish, 2001). This ability to absorb macromolecules without differentiation declines over the first 24 hours of the animal's life. Absorption also declines as the concentration of immunoglobulins which are ingested increases, likely due to competition for absorption (Barrington and Parish, 2001).

This absorption of the colostral immunoglobulins is the most important source of protection against foreign bacteria for a neonatal calf. The immunoglobulin content of colostrum is high, but begins to decline soon after parturition, as does the calf's ability to absorb these immunoglobulins (Lidfors, 1994). It is important, therefore, not only that the offspring suckle, but that they do so quickly after parturition. Failure to suckle can also result in depleted energy stores and hypothermia, decreasing the probability of survival (Gonyou and Stookey, 1987).

2.2.2 Failure of Passive Transfer

Failure of passive transfer refers to the situation where the animal does not absorb adequate levels of colostral immunoglobulins within the first 24 hours (Barrington and Parish, 2001). Immunoglobulin levels can be measured after 24 hours of age and the percentage of calves with failure of passive transfer has been found to range from 15-40% when calves are left with their dams for 24 hours (McGuire and Adams, 1982). While there are some conflicting results (Wittum and Perino, 1995; Weaver et al., 2000; Dewell et al., 2006, for example), it can be said that in general a higher IgG blood level is associated with a lower incidence of disease. Calves with inadequate passive transfer of immunoglobulins are over 5 times more likely to die and over 6 times more likely to get sick prior to weaning (Wittum and Perino, 1995). This increased morbidity in calves is associated with lower weight gains in animals that do not have adequate IgG levels at 24 hours old. Failure of passive transfer is also associated with increased morbidity in the feedlot.

2.2.3 Measurement of Immunoglobulin Transfer

There are several ways that immunoglobulin transfer from the cow to the calf can be measured. One of these ways is the use of a temperature compensating refractometer, which gives a measurement of the total serum protein concentration in the blood. Immunoglobulins constitute a large portion of the protein in neonatal calf serum, and the portion of non-immunoglobulin protein remains fairly constant, so this measure gives a close representation of serum immunoglobulin concentration (Calloway et al., 2002). Serum protein concentrations of 5.5 g/dL or less acts as an accurate predictor of failure of passive transfer of antibodies in calves (Tyler et al., 1999). Other methods to measure immunoglobulin levels in calves include a sodium sulphite turbidity assay or a zinc sulphate turbidity assay. Serum IgG1 concentration can also be detected using radial immunodiffusion. The sodium sulphite assay has been found to correctly classify the largest percentage of calves, depending on the endpoint chosen, followed closely by refractometry. Refractometry is suggested to function well as a routine field test (Tyler et al., 1996).

2.3 Assessment of Maternal Behaviour

Maternal ability and maternal behaviour have been assessed; however, there has not been an agreement on the system of measurement. A summary of tests can be found in Table 2.1. These tests largely rely on subjective measurement. As a result, the inter-observer repeatability may be decreased because of the subjectivity of the assessment. Also, the person giving the score may have pre-existing prejudices about certain animals or breeds.

Maternal behaviour has most commonly been assessed using an arbitrary scale to assign a rating to the cow during handling of her calf. Buddenberg et al. (1986) published one of the first assessments of maternal behaviour using this method. An 11-point scale was used, with scores of 1-3 representing cows that were most aggressive and willing to fight to protect their calf. Cattle that were less aggressive but showed concern/attentiveness scored 4-6, and cows showing little or no concern for calves during human intervention were assigned a score from 7-9. A score of 10-11 indicated that the cow exhibited no maternal instinct. Sandelin et al (2005) adapted this 11-point system into a 4-point scale, and used the new smaller scale to measure maternal behaviour subjectively as well.

Hoppe et al. (2008) conducted tests of maternal behaviour within 24 hours postpartum, also using a subjective score. This test was done during the routine catching and handling of newborn calves. The behavioural response of the dam to these procedures was subjectively scored using a scale from 1 to 5; 1 being the cow stands quietly and shows indifference to the

Table 2.1 Examples of tests used to assess maternal behaviour

Measurement	Reference	Brief test description	Species/Breed
Maternal rating	Buddenberg et al. (1986)	Subjective score from 1 to 11(aggressive to least attentive) while handling calf	Beef cattle/ Hereford, Angus, Charolais and Red Poll
Maternal behaviour score	Sandelin et al. (2005)	Subjective score from 1 to 4 (very aggressive to apathetic) while handling calf	Beef cattle/ various breeds
Maternal protective behaviour score	Hoppe et al. (2008)	Subjective score from 1 to 5 (indifference to dangerous) while ear tagging calf	Beef cattle/ German Angus and Simmental
Stock-person directed aggression	Marchant Forde (2002)	Subjective score from 1-5 (not aggressive to very aggressive)	Swine/Large White X Landrace
Maternal behaviour score	O'Connor et al. (1985)	Subjective score from 1 to 5 (ewe flees and doesn't return to ewe stays close to shepherd) based on response to handling lamb	Sheep/ various breeds
Mothering style	Maestripieri (1993)	Percentage of contacts, approaches, grooming bouts, restraints and rejections by the mother	Rhesus macaques
Maternal temperament score	Morris et al. (1994)	Subjective temperament score from 0 to 5 (cow stand quietly to dangerous) while ear tagging calf	Beef cattle/ various breeds

procedure and 5 representing a cow that is dangerous and tries to push the handler away from the calf. When such subjective systems are used repeatedly by the same observer, it is likely effective in identifying cattle with largely different behavioural responses; however, the subjectivity of these score could render them less reliable across observers.

Marchant Forde (2002) also used a similar 5-point scale (not aggressive to very aggressive) to measure stockperson-directed aggression in swine. This measurement was carried out three times after parturition, at birth of the piglets and 7 and 14 days postpartum. These scores were averaged to give the sow an average aggression score. The use of averages may provide a more accurate individual score, however as maternal aggression declines after parturition then the high levels of aggression could be diluted through the multiple measurements over time.

Assessments are generally done in response to handling of the offspring, and in some cases the fear the animal has of a human may overpower her maternal instincts. A good mother, for example, may appear indifferent because she is avoiding the stockperson. This could be particularly evident in maternal behaviour scores like those used by O’Connor et al (1985) where the subjective scoring system was based on the distance that a ewe retreated from her lamb when a shepherd approached them.

Mothering style, as examined in primates, is determined using more objective measurements such as contact that the mother made with her offspring, grooming of offspring, and rejection behaviours such as holding the offspring away and preventing access to the nipple (Maestripieri, 1993). These measurements can more effectively quantify certain aspects of maternal behaviour; however, certain behaviours are still open to interpretation and may not precisely indicate maternal ability. These types of measurements also require extensive observations, many of which are not practical in a field setting. These measurements are also not useful in measuring aggression towards people, which was not considered by Maestripieri (1993).

Other research has looked at individual behaviours that are considered to be indicative of level of maternal care given. Some of these behaviours that can be measured immediately after parturition include duration of licking bouts, delay before eating, time facing the calf, interruption of suckling, as well as number of times a cow butted and kicked her calf (Edwards and Broom, 1982). These measurements represent more objective measures, however can be affected by management procedures, and while they may well reflect maternal care, do not measure maternal aggression.

2.4 Factors Affecting Maternal Behaviour

2.4.1 Breed

In regards to maternal behaviour, nearly all beef breeds of cattle have been developed with a focus on their ability to raise a calf to weaning. In contrast, dairy breeds have traditionally been selected for milk production. Inadvertently or in some cases intentionally, dairy breeds may have been selected against some aspects of maternal behaviour such as the ability to let down milk only in the presence of a calf (Edwards and Broom, 1982). As dairy calves are separated from their mother soon after birth, any detrimental effects of poor maternal behaviour are short lived and certain management techniques, such as feeding colostrum, may be used to prevent any long term effects. Le Neindre (1989) found that breed had a major impact on mother-offspring relationship when he compared Friesian (a dairy breed) and Salers (a beef breed). Salers calves suckled and were licked longer than Friesian calves and Friesian cows were suckled more often by calves that were not their own.

German Angus cows (a beef breed) have been found to pay more attention to their calves during handling and are more likely to actively defend their calves as compared to Simmental cows (a dual purpose dairy and beef breed). This defence may include trying to push the handler away from the calf (Hoppe et al., 2008). Angus cows have also been found to be more aggressive after parturition than Charolais, Red Poll and Hereford cattle (Buddenberg et al., 1986; Morris et al., 1994; Sandelin et al., 2005; Hoppe et al., 2008). These breed differences make it surprising that Buddenberg et al. (1986) estimated heritability of maternal rating of cattle at only 0.06 ± 0.01. Maternal behaviour of sows, as measured by response to piglets being handled, was also found to be low at 0.08 (Løvendahl et al., 2005). Other heritability estimates measuring maternal care and behaviour of various species range from 0.20 to 0.29 (Grandinson, 2005). These variable and generally low estimates could result from a lack of consistent tests that are used to measure maternal behaviour, as well as the extensive use of subjective scoring. Certain behaviour parameters that indicate good maternal behaviour such as licking behaviour are difficult to record and may require extensive observations, and as such are not particularly useful as selection traits, despite the moderate heritability (0.32 ±0.23 for licking time) of some of these traits (Le Neindre et al., 2002; Grandinson, 2005).

Certain breeds could have differences in social anxiety, changing their protective style (Dwyer and Lawrence, 2000). The emotionality of different breeds may be involved in differences that become apparent when investigating maternal behaviour. Different breeds of sheep also seem to have different consistencies in behaviours across parities (Dwyer and Lawrence, 2000). Ewes from more primitive, hill and upland breeds, which have undergone less selection and human intervention generally exhibit higher levels of maternal care, and are more reactive than ewes of intensively selected breeds (Dwyer, 2008). Changes in cattle likely mirror those in sheep that have been brought about by domestication and human selection. Breeds which have undergone increased selection for certain traits and have been subjected to higher levels of human interference could exhibit different maternal behaviour than those which have undergone comparatively little interference and artificial selection.

2.4.2 Maternal Experience

Maternal experience has been shown to affect certain responses to offspring. Inexperienced ewes appear to specifically show increased rejection of their lambs in comparison to experienced ewes, but inexperience does not affect all behaviours equally. It has been suggested that this is because of greater anxiety and neophobia at the presence of the lamb, or because of reduced neuroendocrine response in the primiparous female. It appears that these differences of primiparous females are not due to age, but rather to inexperience, however these factors are generally confounded in animals (Dwyer and Lawrence, 2000).

Increased maternal experience in ewes has been found to reduce negative maternal behaviours of the ewe after parturition such as backing away from or butting the lamb. Primiparous ewes attempt to keep the newborn lamb directly in front of them, and will often back away or circle the lamb if it moves alongside the ewe in an attempt to suckle (O'Connor et al., 1992). Conversely, grooming behaviours of the ewe are not affected by maternal experience. For primiparous mothers, a negative relationship exists between rejection behaviours and care behaviours; whereas these behaviours are independent in multiparous ewes (Dwyer and Lawrence, 2000).

The lactation number of cows has also been found to be significant when maternal aggression is considered (Hoppe et al., 2008). After the first calving, the lowest maternal scores tend to be given, likely because of the lack of experience the cow has at raising and protecting a calf. There also seems to be an interaction between breed and lactation number, as Angus cows typically have a greater increase in maternal protective scores from fourth to seventh calving when compared to Simmental cows (Hoppe et al., 2008). There are conflicting reports past the seventh calving, as Buddenberg et al. (1986) found a continued increase in maternal scores after whereas Hoppe et al. (2008) reported lower scores for cows in their eighth lactation, but this may be because highly aggressive cows were culled.

Despite the importance of maternal experience, across-parity consistent “maternal styles” have been identified in primates (Maestripieri, 1993). Maternal behaviour in sheep immediately after parturition has also been found to follow certain consistencies, particularly rejection behaviours such as butting and withdrawing from the lamb and care/warmth behaviours such as short latency to groom the lamb, nosing the lamb, and moving towards the lamb (Dwyer and Lawrence, 2000). Maternal experience may be important in ‘priming’ the animal physiologically and reducing the neophobic response which may result in decreased aggression towards offspring in experienced mothers.

2.5 Hormones

There is a complex connection between the central nervous system and the endocrine system in the days leading up to parturition. The sensory stimuli of the offspring and the environmental conditions interact with these systems to trigger and maintain maternal behaviours. Specific regions of the hypothalamus in rodents have been linked with regulation of maternal behaviours such as grouping of pups, providing warmth, licking anogenital regions and other tactile stimulation (Poletto, 2010). Other areas of the brain are thought to play a role in identifying olfactory cues, which are vitally important for the onset of maternal receptiveness and offspring recognition, as well as development of the mother-offspring bond. Hormone profiles change during the birthing process and are essential for such things as the development of the mother-offspring bond and the let down of milk. The hormone levels in the immediate postpartum period of the cow have not been well studied, particularly in relation to maternal behaviour. Most behavioural literature is based on responses from rodents, however there is some information based on hormonal responses of sheep.

2.5.1 Oxytocin

The hormone oxytocin is one that is vital in many aspects of maternal behaviour. Oxytocin appears to have varying roles in different species and is thought to play a much larger role in maternal behaviour of sheep than in mice and rats (Kendrick, 2000). The role of oxytocin in maternal behaviour of cattle has not been investigated; however, cattle and sheep have many similarities, so it is quite possible that oxytocin plays a similar role in both species.

Oxytocin's release is stimulated by both sexual and reproductive stimuli such as copulation, birth, olfactory stimuli and suckling, as well as other stimuli such as grooming and exposure to offspring. It is synthesized in the hypothalamus of the brain and has effects both centrally and peripherally, with the release facilitating milk ejection, parturition, and other maternal behaviours (Campbell, 2008).

Oxytocin is thought to be involved in the establishment of maternal behaviour, but not in the maintenance of these behaviours. This is likely because oxytocin is thought to induce other transmitters in specific brain regions that maintain maternal behaviour. Oxytocin most likely has a general, fast-acting course of action that is necessary in situations where speed, reliability and specificity are important, such as immediately after parturition. Oxytocin reactivity and receptor mRNA expression increases in the olfactory bulb in sheep soon after parturition (Kendrick, 2000). Because the olfactory bulb is involved in the development of olfactory memory, oxytocin is thought to be involved in the formation of the maternal bond and olfactory recognition. Once the proper mechanism and behavioural changes are established, it is no longer necessary to activate transmitters.

The increase of oxytocin alone is not enough to fully induce maternal behaviours; both vaginocervical stimulation and oestrogen priming are also necessary, however oxytocin alone does reduce behaviours associated with offspring rejection (Dwyer et al., 1999). Oxytocin has also been found to reduce aggression towards offspring in mice and simultaneously increase aggression towards intruders. This may be due to oxytocin's inhibition of corticotrophin releasing factor which controls activity in the hypothalamic pituitary axis and inhibits maternal aggression. Oxytocin also decreases the level of fearful behaviour shown by an animal (Campbell, 2008).

2.5.2 Oestradiol and Progesterone

Maternal behaviour is affected by levels of oestradiol and progesterone and the ratio of the two hormones. Progesterone concentrations, which are vital in maintaining pregnancy, gradually decline towards the beginning of parturition (McLean et al., 1998). The decrease in progesterone concentrations before parturition occurs simultaneous to a rise in oestrogen levels, which return to basal levels soon after parturition (Nowak et al., 2000). Progesterone levels themselves have little effect on maternal behaviour, however high concentrations can inhibit oxytocin (Dwyer et al., 2004).

Oestradiol and progesterone work together to increase central oxytocin and oxytocin receptor expression, which is known to be important for development of maternal behaviour (Dwyer et al., 2004). Oestradiol and oestradiol-progesterone ratio levels in ewes during late gestation have been shown to be related to maternal behaviours such as grooming, and oestradiol-progesterone ratios were also found to be significantly higher before parturition in gilts that subsequently savaged their piglets (McLean et al., 1998; Dwyer et al., 1999). Adequate hormone concentrations and ratios are important to ensure that proper maternal behaviour is exhibited. An inappropriate increase or decrease in hormones crucial to maternal behaviour can result in varying responses that may lead to unwanted maternal behaviour.

While oestradiol and progesterone are important for the initiation of certain maternal behaviours, the full complement of behaviours can only be stimulated with both hormone treatment and vaginal and cervical stimulation in multiparous ewes (Kendrick and Keverne, 1991). Vaginocervical stimulation also further reduces aggression and negative behaviours such as withdrawal from the lamb in nulliparous and multiparous ewes. This is likely due to the effect that vaginocervical stimulation has on oxytocin release.

Disruption of parturition can impact the delivery of the offspring. In sows, moving parturient animals doubled the time to delivery of the next piglet and decreased the level of circulating oxytocin compared to sows left undisturbed, possibly due to increased stress levels (Lawrence et al., 1992). Increased stress causes a release of opioids, which consequently inhibit oxytocin (Janczak et al, 2003). Cortisol concentrations in ewes at parturition are in fact negatively associated with maternal care (Dwyer et al., 2004). Inhibition of oxytocin can also lead to delayed parturition and milk let down, as well as an inhibition or reduction of other maternal behaviours. The altered hormone levels are the probable cause of increased mis-mothering seen in animals that require assistance to deliver the foetus, as additional handling and interference is inevitable in these situations.

2.6 Predation

While maternal behaviour is important to initiate the proper maternal response and ensure the calf obtains colostrum, there are continual risks to calves that must be considered, such as environmental extremes and predation. The loss of calves to predators has a large financial impact on producers. Cattle and calf losses (due to predation) accounted for over $51.6 million lost by producers in the United States in 2000 and $92.7 million lost in 2005 (US Department of Agriculture, 2001; 2006). Producers in the US also spent $184.9 million on non-lethal predator control for cattle in 2000.

Predation rarely involves full grown animals, whereas calf deaths before weaning are much more common. In 2000, 145,000 cattle and calves were lost due to predation in the United States (excluding Alaska), of these 126,000 were calves under 226.8 kg (500 lbs) (US Department of Agriculture, 2001). This total rose to 190,000 in 2005, of which 156,000 were calves (US Department of Agriculture, 2006). As beef production becomes more extensive and herd sizes grow, cattle have an increased risk of contact with predators. Calving has also shifted from early spring (January to March) to late spring and early summer (April to June) on many farms. Consequently, these cows are often calving on pastures where the contact with predators is increased. Calving later in the year also synchronizes the arrival of calves with the arrival of predators' offspring which increases the adult predator's energy demand considerably.

2.6.1 Protection of the Offspring from Predators

Predation accounts for 4.7% of total cattle losses in the United States (US Department of Agriculture, 2006). While this may seem like a small number, and is by no means the most prevalent cause of calf death, it still represents an area of lost revenue and concern for cattle producers. It is clear that the maternal protection of the calf is important on many farms to ensure the survival of the calf. No doubt some producers select for overly aggressive females or allow them to stay in the herd believing they improve the likelihood that the calf will survive until weaning. While it is known that adequate maternal protection does increase the offspring's chance of survival, it has not been shown whether excessive maternal protection increases the offspring's chance of survival further.

In nature, survival of offspring is vital to ensure an individual's reproductive fitness. Young are vulnerable to predators, and in order to defend the young, anti-predator strategies have developed in adults (Nowak et al, 2000). Many animals, including cattle, will defend their offspring against predators to improve their chances of survival. This can involve attacking the predator either to deter it from pursuing the offspring or to defend the offspring against the predator. The efforts of the mother to hide her offspring and lead it away from danger may be equally important in protecting the young from predation. Dams have also been seen to lure predators away or confuse them in order to protect their offspring (Lent, 1974).

Domestication of cattle has led to changes through selection for increased meat and milk production. Domestication of cattle and husbandry practices may also have reduced predation risks, and it is possible that anti-predatory behaviours have been reduced through this selection, as found in sheep (Hansen et al., 2001). However, in North America's extensive beef cattle production practices predators such as coyotes, wolves and bears are somewhat common, so domesticated cattle may still be under some selection pressure to defend their young against predators.

2.7 Stock-person Directed Aggression

While protection of the calf against predators is desirable, cattle can become dangerous to work with if they also defend their young against humans attempting to handle their calf. A protective cow can easily injure a stockperson, and dealing with these animals in production systems also increases the difficulty of performing certain procedures that are important for record keeping, identification and health.

Stock-person directed aggression could occur from the increased maternal protectiveness associated with maternal care, defensive aggression or from dominance aggression (Marchant Forde, 2002). The manifestation of this aggression may depend on the quality and quantity of interactions that the animal has with the stock-person. Humans may be perceived as a threat to a calf, especially where cattle are handled infrequently or are kept in extensive rearing systems (Turner and Lawrence, 2007). As beef cattle farming become more extensive, stock-person directed aggression is becoming one of the greatest threats to handler safety. Selection for cattle that can calve outdoors without assistance and raise a calf to weaning may increase the protective behaviours shown by the cow. It is likely however, that a cow can effectively protect her calf and at the same time not show stock-person directed aggression.

2.7.1 Species Recognition

It is probable that a cow is able to tell the difference between humans and predators such as wolves and coyotes, so it is important for safety reasons to have cattle that do not generalise humans as predators. Sheep can differentiate between stimuli and show stronger anti-predator responses when presented with carnivore stimuli (a live dog and 3 predator models) in comparison to "blind stimuli" (novel objects and a human) in field tests (Hansen et al., 2001). Arena tests have also shown that sheep exhibit less fear-related behaviour, are less vigilant and explore more when presented with a human compared to when they are presented with a dog (Beausoleil et al., 2005).

Cattle respond to predator stimuli and are more vigilant and forage less when exposed to a model wolf compared to a model deer, mountain lion and control (Kluever et al., 2009). These cattle had been previously exposed to situations where coyotes had preyed on calves. The authors also observed that cattle are able to discriminate between wild and domestic canines, however these observations could be due to the postures that the domestic dog adopted that were not interpreted as threatening by the cattle.

If cattle can indeed distinguish between a predator and an animal (or human) that is not a threat, there should be no reason for stock-person directed aggression to appear. The optimal situation would be to have cattle that will actively protect or defend their offspring against a predator if the need arises, but will not exhibit aggressive behaviour toward people while being handled.

2.7.2 Safety Concerns Associated with Stock-person Directed Aggression

Agriculture is the fourth most hazardous industry in Canada based on work-related fatalities, behind mining, logging and forestry (Pickett et al., 1999). In Canada from 1990 to 2004, 23 people were killed by cows. In the same period, 29 people were killed by bulls, which are generally considered much more dangerous than cows (Canadian Agriculture Injury Surveillance Program, 2008). The vast majority of animal related fatalities occurred when the victim was struck by the animal (Canadian Agriculture Injury Surveillance Program, 2008).

Working with animals is also the most common cause of agriculture injury that results in hospitalization (18.7%); with cows and bulls causing most injuries in men (Canadian Agriculture Injury Surveillance Program, 2003). Cattle related injuries are most common from March to May and are not surprisingly, often related to calving or recently calved cows. Interaction with these animals is often necessary, and unfortunately injuries and fatalities occur every year.

Agricultural injury surveillance in Iowa, Kansas, Missouri and Nebraska from 2003 to 2008 revealed 21 deaths caused by cattle, 6 of these by individual cows. In some cases the animal was known to be aggressive, and in 16 of the 21 fatalities, the animal was determined to have purposefully struck the person. Beef cows with calves caused 14% of these fatalities and a common circumstance determined as a cause of death involved cows becoming aggressive towards people while they were removing dead, newborn calves (Centers for Disease Control and Prevention, 2009).

As production of beef cattle becomes more extensive, the level of interaction between stockpersons and their cattle is decreasing (Hoppe et al., 2008). The calving period is often the most interactive time period for cattle and producers. In Canada all cattle must be tagged before they are sold, therefore it is common practice to tag calves when they are a few hours or days old. This time coincides with the period of highest maternal protective behaviour, and may cause an aggressive cow to become a danger to a producer (Turner and Lawrence, 2007).

It is clear that there are considerable dangers involved with working with livestock on farms across North America. Farming is often an independent business, and those at the highest risk of fatal injuries are men over 60 that are owner-operators of farms, likely because they often work in isolation (Pickett et al., 1999). There appears to be no trend in the number of animal related fatalities over the years, and the number varies greatly (Canadian Agricultural Injury Surveillance Program, 2008). These deaths are largely preventable, and more needs to be done to investigate the causation and potential preventative measure that can be taken.

2.8 Temperament

Temperament in livestock can be described as an animal’s behavioural response to handling by humans (Burrow, 1997), whereas in other literature (for example primate literature) temperament refers to behavioural styles or tendencies that show continuity over time (Clarke and Boinski, 1995). The definition given for primates may be more accurate, as an animal’s response to handling can be masked through training or taming, although few livestock animals are trained. The response to handling has thus been used to assess the temperament of beef cattle. An animal’s temperament can consist of behavioural responses of fear, nervousness, escape, docility, and aggressiveness (Burrow, 1997). The temperament of an animal is used to describe its behavioural and physiological reactivity. The physiological response is largely under control of the sympathetic nervous system (Clarke and Boinski, 1995).

Temperament of cattle is known to affect their productivity, as it has been found that cattle that react calmly to handling by people have a higher average daily gain (Voisinet et al., 1997). Temperament is largely consistent across time and situations, so it is feasible that an animals' temperament could affect its response to people at the time of calving.

2.8.1 Assessing Temperament

Temperament has been assessed by many different ways in many different species. These tests have been previously classified as non-restrained tests, restrained tests, dairy temperament score, dominance tests, maternal temperament, and ease of movement tests (Burrow, 1997; Sebastian, 2007). Non-restrained tests include approach/avoidance tests, open field tests, arena tests and flight distance measurements. Restrained tests usually consist of a subjective temperament score being given in response to restraint in a scale, chute and/or bail. Dairy temperament scores are largely subjective scores based on docility, nervousness and aggression. Ease of movement tests are based on the time that it takes to move animals through a set route, usually including a chute or scale.

Scoring techniques such as human-approach tests, novel object tests, approachability and open field tests have been used to assess temperament of livestock in large areas. These tests have been criticised somewhat because of the potential variation in testing conditions. Open field tests also do not allow for adequate record of discrete behaviour, which Kilgour (1975), suggests may provide a better indication of temperament. Subjective scores are also often used, however the repeatability between observers is questionable, and correlation to other tests has not been found (Burrow and Corbet, 2000; Kilgour, 1975).

Other tests focus mainly on response to handling and are completed in handling systems. These include exertion force, a movement-measuring-device, and exit time. Exertion force is measured using strain gauges mounted on the headgate. This gives a quantitative measurement (in millivolts) of the amount of force an animal exerts against the headgate during restraint which could be an indirect measure of temperament (Sebastian, 2007). Exit velocity provides another quantitative measurement of temperament, where the time an animal takes to travel a certain distance is recorded, with calmer animals taking a longer time (Burrow et al., 1988). Exit velocity is considered a reliable measure of temperament, and has been correlated to cortisol levels (Curley et al., 2006). Exit speed is also considered moderately heritable, even if only one measurement is made, and the heritability increases if several measurements are used (Burrow and Corbet, 2000).

2.9 Temperament and Maternal Behaviour

2.9.1 Response to People and Conspecifics

An animals' response towards people as well as towards conspecifics can be used to predict the occurrence of maternal aggression in sows. Piglets tested at 8 weeks of age that showed reduced fear of humans had improved reproductive ability as sows, measured as shorter farrowing duration, fewer stillborn piglets, and higher piglet survival after birth (Janczak et al 2003). Also, gilts that savaged their piglets are more likely to exhibit 'shy' behaviour during a pre-farrowing human approach test, while gilts that were highly aggressive towards stockpersons after farrowing were more likely to show 'bold' behaviour in the same test (Marchant Forde, 2002). These results suggest that there are certain aspects of an animal's temperament that can be detected early on in life that will relate to that animal's behaviour in a very different situation.

Aggression in sows at mixing has also been found to be inversely genetically related to maternal behaviour. Sows that are less aggressive have been found to be more alert as mothers, and respond more to piglets screams than more aggressive sows (Løvendahl et al., 2005). Conversely, gilts that savaged their piglets were found to exhibit significantly lower levels of aggression when housed in groups before farrowing (McLean et al., 1998). Extreme temperament differences may be related to coping styles and may therefore lead to different reactions after parturition.

2.9.2 Maternal Style

Maternal style is a term that has been used in non-human primates to describe differences that are consistent in a certain animal from one offspring to the next, and also over differing offspring ages (Maestripieri, 1993). Temperament, or the emotional reactivity of a mother, and her maternal style have been found to be linked in macaques, where anxious mothers are more protective and confident mothers are more likely to reject their young. Maternal anxiety, which was measured by visual monitoring of the young, was found to account for more of the variability of maternal protectiveness than other characteristics such as age, experience, dominance, sex of the offspring, or number of immature offspring in the group. The amount of visual monitoring that the mother did of other individuals in the group when she was in contact with the offspring also explained a significant part of the variation in mothering style. It is possible that certain aspects of temperament or anxiety may be consistent with maternal anxiety, and therefore maternal style.

Certain maternal styles (‘rejecting’, ‘aggression’ and ‘care/warmth’) have also been identified in sheep immediately after parturition by observing behaviours such as grooming, butting, withdrawing, and prevention of sucking attempts by the lamb. It has not been determined if these styles persist beyond a short period after the ewe gives birth or if they are related to the response that the ewe shows when her lamb is handled, but they are found to have some consistency across parities of a certain ewe (Dwyer and Lawrence, 2000).

2.9.3 Fear Response

Fearfulness in animals can be defined as a basic trait of the animal’s personality representing the individual’s inclination to be easily frightened in a variety of potentially aversive situations (Boissy, 1998). The reaction to aversive events is not automatic with the major controls of a fear response being the interaction between the psychophysical properties of the aversive event, the neuroendocrine state of the individual and both physical and social situational factors that may offer the individual more control over the event. The stimulus-response relationship must therefore be considered when examining fear and anxiety states in animals.

Certain measures of maternal behaviour are unfortunately intertwined with the animals’ fearfulness of humans, such as a response to handling of offspring. Maternal behaviour scores (MBS) developed by O’Connor et al. (1985) are widely used in scientific research to assess a ewe’s response to handling of her offspring. This ‘maternal behaviour score’ unfortunately may not reflect maternal behaviour, but instead reflect the animal’s response to humans, as suggested by Dwyer and Lawrence (1998). The authors noted that there were differences between the responses of animals of the two breeds that received the same score. Suffolk ewes that received a low MBS were frequently eating and not responsive, whereas Scottish Blackface ewes that received a low MBS were active and vocal. The two breeds had significant differences in maternal behaviour, but the median MBS was not different, suggesting that the MBS is not an accurate assessment of maternal behaviour, and instead reflects fear of the stockperson. Fearfulness of humans may result in animals having reduced maternal care within certain proximity of humans because of their fear response to those humans. This fear response could also impact the accuracy of measurements made in the presence of humans.

2.9.4 Assessment of the Relationship between Temperament and Maternal Behaviour

The link between temperament and maternal behaviour and performance has been investigated recently, as seen in Table 2.2. While these studies have investigated very different aspects of maternal behaviour and temperament, correlations between the temperament of an animal and its maternal productivity and behaviour have been found. These studies have found that extremes in temperament are related to certain aspects of maternal behaviour.

2.10 Behaviour as Possible Selection Criteria

Although optimal maternal behaviour is important in beef production, it can be difficult to select animals based on this parameter. The primary difficulty in selecting animals based on maternal behaviour or ability is that the best measure of maternal performance is the animal's own success at raising offspring. This obviously cannot be measured until the dam raises her first offspring, which in cattle is usually not until they reach two years of age. Genetics plays a role, but the selection intensity of the paternal line is also reduced somewhat because direct measurements of female traits cannot be obtained from a male animal. Measurement of female traits of a paternal line is therefore indirect and based on the males' dam and progeny. It would be beneficial to have criteria that could be used to select both females and males early in life before they are incorporated into the herd and breeding stock.

The behaviour of ewes and rams in an arena test has been shown to differ between animals selected for enhanced ability to rear lambs and unselected animals (Kilgour, 1998). The specific behaviour that differed was the total distance travelled while in an arena alone with a stationary human. Ewes and rams selected for rearing ability travelled significantly less total distance than those not selected for rearing ability at 6, 12 and 20 months of age. Ewes and rams from the selected flock also vocalized less at 6 months than the unselected animals. This difference was still apparent at 12 months for ewes, but not rams, and no difference was detected at 20 months in either sex. It appears that the animals that were not selected for lamb rearing ability are more agitated when alone with a human. Using these behaviours to select replacement animals could have definite advantages. Selection could occur earlier, before animals have entered the breeding flock, and it can also be used to select rams, increasing genetic progress. Unfortunately, it is not

Table 2.2 Assessment of temperament and its relationship to maternal behaviour

Measurement	**Reference**	**Brief test description**	**Summary of findings**	**Species/Age at temperament test**
Fear of humans and maternal ability	Janczak et al. (2003)	Human approach test and novel object test; Farrowing duration, risk related sow behaviour, number of live piglets	Higher fear of humans= decreased maternal ability	Swine/ 8 weeks
Shy/bold and maternal aggression	Marchant Forde (2002)	Human approach test; Savaging, stock-person directed aggression score	Savage piglets=more likely to be shy; Stock-person directed aggression=more likely to be bold	Swine/ Gilts (6-8 weeks before parturition)
Aggression at mixing and response to piglets	Løvendahl et al. (2005)	Aggressive encounters at mixing; Response to piglet vocalisation	Less aggressive sows respond stronger to vocalisations	Swine/ Sows
Aggression at mixing and maternal aggression	McLean et al. (1998)	Aggressive encounters between animals pre-farrowing; Aggression towards piglets	Gilts showing low levels of maternal aggression are more likely to exhibit high levels of aggression during pregnancy	Swine/ Gilts
Human approach/ avoidance and maternal ability	Kilgour (1998)	Arena behaviour, approach; Avoidance of humans	Animals selected for lamb rearing ability are less agitated when in presence of human	Sheep/ Rams and ewes (6, 12, 20 months of age)
Emotional reactivity and maternal behaviour	Maestripieri (1993)	Visual monitoring and scratching/ maternal warmth and rejection	Maternal and social anxiety shapes maternal protectiveness	Rhesus macaques/ 4 to 16 years

clear from these studies if animals that are selected for reduced fear will indeed have improved lamb rearing ability (i.e. correlation vs. causation).

2.10.1 Natural Selection

If certain temperaments are related to improved productivity or survival, these temperaments should persist in wild populations. In a population of wild bighorn sheep, ewes that were both bold and docile (based on trappability and behaviour during handling) were rare. The authors suggest that natural selection works against this combination of traits, allowing for differing temperaments to evolve. In this population, bold or docile ewes reproduced earlier than shy or non-docile ewes. Bold ewes also had an increased weaning success (Réale et al., 2000). In years with high predation by cougars, selection pressure favoured bold ewes; however, this was not seen in years with low predation pressure (Réale and Festa-Bianchet, 2003). Old docile ewes were also more vulnerable to predation than less docile ewes in years of high predation. These results indicate that selective pressure may be exerted on both ewes that are shy and ewes that are not docile, leading to the divergence of temperament.

2.11 Conclusions

Maternal behaviour is an important part of beef cattle production. Normal maternal behaviour surrounding parturition includes selection of a birth site, licking the calf and facilitating suckling. These behaviours can be affected by such things as the maternal experience of the dam. Hormones also play a vital role in initiating and maintaining maternal acceptance of the young and other maternal behaviours. Cattle which care for their calf are desirable in order to ensure productivity and health of that calf. Cattle may also be required to protect their calf from predators; however, this protective behaviour can be dangerous if it is extended towards people. Research has shown that cattle can distinguish between predators and non-threatening species and thus aggression towards people need not be tolerated.

Temperament is consistent across time and situations and has been shown to be related to certain aspects of maternal behaviour in many species including swine and rhesus macaques. Gilts that savaged their piglets were more likely to show shy behaviour in a pre-farrowing human approach test, whereas gilts that were highly aggressive towards the stockperson following farrowing were more likely to show bold behaviours in the same test. In rhesus macaques, individuals which showed high levels of social or maternal anxiety also developed a highly protective mothering style. These results indicate that there are indeed consistencies between an animal's response to people, conspecifics or situations and its response to its offspring.

The link between temperament and maternal behaviour has not been examined in cattle where it could have practical uses in the selection of breeding animals. This study examined the connection between pre-calving temperament in beef cattle as measured by a response to handling by people and various measurements associated with maternal aggression and maternal care.

3 PREDICTING MATERNAL BEHAVIOUR USING TEMPERAMENT TESTS

3.1 Introduction

Maternal qualities in domestic animals are generally determined after an animal has given birth for the first time. Although genetics and experience influences the maternal behaviour a cow exhibits, the best determination is her own performance as a mother. This makes it somewhat difficult to select animals based on maternal ability before they are established in the herd.

Maternal behaviour is most often measured using a subjective score during handling of the offspring; however, Dwyer and Lawrence (1998) found that these scores may be inconsistent as they are confounded with the dam's fear of people. Other measurements, such as licking time, may more directly indicate the maternal ability of a certain animal; unfortunately these measurements are time consuming and somewhat difficult to record (Edwards and Broom, 1982). Other measurements that can be easily recorded during routine handling of the offspring, such as vocalisations and time for the dam and offspring to reunite may provide an effective and easy measurement of maternal behaviour.

Temperament in animals is generally consistent across time and situations, and has been found to be related to production traits such as growth (Voisinet et al., 1997). There is a possibility that the temperament of cows could be used to predict their maternal behaviour in terms of their response to people as well as to their calves. This link has been found in swine (Marchant Forde, 2002; Janczak et al., 2003), sheep (Kilgour, 1998) and rhesus macaques (Maestripieri, 1993). It is possible that this link exists in cattle and could be used to select breeding animals based on expectations of their maternal behaviour.

The ancestors of domestic cattle developed protective behaviours in order to improve survival of their offspring. While domestication has somewhat diminished the need for these behaviours by decreasing the animals' interactions with predators, these protective behaviours are still present and in some cases are directed towards humans that interact with these animals. Cattle have previously been found to distinguish between different types of predators (Kluever et al., 2009), and sheep have been found to respond differently when presented with humans compared to carnivores (Hansen et al., 2001; Beausoleil et al., 2005). The response a cow has to a stockperson handling her calf therefore may not be indicative of her response to a predator.

The goal of this study was to examine the relationship between the reaction of cattle to handling in the chute and their maternal behaviour, including aggression towards humans handling their calf. Another goal of this study was to determine whether the response of cattle towards a predator was related to their response towards humans. The responses of parturient cattle to humans handling their calf and their response to a potential predator were therefore examined, quantified and compared to the temperament of the animal. In cattle production, it would be most practical to select animals that are docile in handling situations and effective mothers if these animals can be identified. Ideally, a paraxial selection could be undertaken, allowing for selection of cattle that are reactive towards predators, but show low aggression and reactivity towards humans, reducing the safety risks associated with recently calved cows.

3.2 Materials and Methods

3.2.1 Animals and Housing

Experimental animals consisted of 119 multiparous and 65 primiparous beef cattle in year 1 and 112 multiparous and 57 primiparous beef cattle in year 2. A total of 99 cattle from year 1 were tested again in year 2 (74 multiparous and 25 that were primiparous during year 1). Cattle were of mixed breeds (primarily Hereford, but also some Gelbvieh and Simmental crosses) and were housed at the University of Saskatchewan Goodale Research Farm. The calving season ran from the end of March until the end of May.

In the month before the beginning of the calving season, all animals were brought through the chute complex and weighed and body condition scored using a 1-5 scale (Table 3.1) (Lowman et al., 1976). Before calving, primiparous and multiparous animals were separated into two groups. Primiparous animals were then split into 4 equal sized groups, while multiparous cows were maintained in one large group, as per farm management practices. All animals were fed *ad libitum* hay as well as given access to silage. The animals were kept in straw-bedded corrals with access to a south facing shed for the duration of the experiment.

Table 3.1 Body condition scoring system for beef cows (Adapted from Lowman et al., 1976)

Body Condition Score	Description
1	**Emaciated**; all skeletal structures are prominently visible and sharp to touch. No muscle tissue is evident and no external fat is present.
2	**Thin**; vertebrae along the top line are prominent and can be felt, but are not as sharp. Muscle tissue is evident but not abundant. The short ribs can be individually identified and are sharp. Individual ribs can be seen; some tissue cover around hook and tail head.
3	**Good**; increased fat cover over the ribs, ribcage is only slightly visible. Muscle tissue is nearing the maximum, obvious fat deposits behind the front shoulder. Areas around the tail head are well filled but not rounded.
4	**Moderately fat**; the bone structure is no longer noticeable. Individual short ribs cannot be felt, even with firm pressure. Folds of fat are beginning to develop over the ribs. Fat cover around the tail head is evident on both sides.
5	**Very fat/obese**; blocky appearance, bone structure is not noticeable. Back bone appears flat and cannot be felt. Folds of fat are apparent and the hip bones and tail head on both sides are completely buried in fat. Animal's mobility is impaired by large amounts of fat.

3.2.2 Pre-calving Temperament Test

The initial test of pre-calving temperament was conducted over 2 days, during the month preceding the beginning of the calving season. Each animal was restrained in a squeeze chute using a headgate equipped with strain gauges, which measured the relative amount of force exerted by the cow on the headgate due to struggle (Schwartzkopf-Genswein et al., 1997). Output was measured in millivolts (mV). Strain gauge signals were amplified using a signal conditioning unit (Model 2310 signal conditioning amplifier, Vishay Measurements Group, Raleigh, NC) and acquired using National Instruments USB-6008 multi-function data acquisition unit. Data were acquired in a computer program (National Instruments Labview Environment language), which transferred the output onto a spreadsheet. Strain gauges were sampled at 20Hz. Data for each animal were stored as a separate file. A summary file calculated the mean voltage, standard deviation, maximum and minimum for each animal during each of three timed periods during the handling test.

After a 10s settling period in the headgate, a 10s baseline period was allowed to elapse during which the strain gauge sample designated ‘baseline’ was recorded. During this first 20s, each animal was given a temperament score on a 1-5 scale by the same observer (Table 3.2) (Grandin, 1993; Sebastian, 2007).

After the 20s had elapsed, the observer moved to a spot located approximately 1m in front of the headgate. The observer stood motionless for 10s during which the strain gauge sample designated ‘STAND’ was recorded. The observer then reached out and attempted to keep her hand approximately 2cm away from the forehead of the cow for an additional 10s during which the strain gauge sample designated ‘REACH’ was recorded. This procedure was done to observe the animal’s response to a person who was close to the animal. As the observer kept her hand off the cow’s forehead, it gave the opportunity for the animal to make contact with the observer or to withdraw. ‘Contact STAND’ and ‘Contact REACH’ were recorded in these two periods respectively. These variables recorded the type (or lack of) contact that the cow made with the person. If the animal tossed her head or butted the hand of the person, ‘negative contact’ was recorded. If the animal sniffed the person, ‘positive contact’ was recorded. If the animal did not make either type of contact with the person, ‘no contact’ was recorded. This procedure simulated a potential interaction between a human and animal in commercial beef cattle production. The animal was then released from the chute and exit speed was recorded via a

Table 3.2 Subjective chute score guidelines (Grandin, 1993)

Score	Description
1	Very little or no movement
2	Low amplitude movements or ≤ 2 forceful kicks or shakes
3	More than 2 violent/forceful kicks, shakes, jumps, etc
4	Nearly continuous violent movement
5	Continuous violent movement

camera as the animal travelled down an alleyway between two points 4.29m apart. This entire process was filmed for evaluation at a later date. Cattle were then returned to their home pen.

3.2.3 Pre-breeding Temperament Test

Temperament tests were also performed in the month before breeding on the replacement heifers that would calve in year 2. These tests were the same as those performed before calving, described above, involving subjective chute score, response to a person while the animal was being restrained in the chute, strain gauge measurements and exit speed.

3.2.4 Post-calving Maternal Behaviour Test

After calving, cows and calves were moved into a maternity pen to allow close surveillance and health checks of the pairs by the farm staff. This pen is where the calf underwent processing by the farm staff at a median of 44.5 h post calving in year 1 and 46.0 h post calving in year 2, with a range of 5 to 123 h of age. The processing was filmed for later analysis of the cow's behaviour. The behaviour of the cow was evaluated while routine procedures were performed on the calf by the farm staff. These procedures included ear-tagging, castration of males using an elastic band, weighing, and giving 2 injections (1cc of Vitamin AD-500 and 1cc of Vitamin E). Ear punches were also taken in order to test calves for BVD. The response of the cow to her calf as well as her response to the stockperson during these procedures was video recorded. Two farm staff were involved with the processing of each calf. One staff member performed the procedures and the other acted as a guard against potentially aggressive mother cows.

The behaviour of the stockperson responsible for protecting the person processing the calf was classified into one of three groups (Table 3.3). Cows were also given a maternal score based on their behaviour and response during processing (Table 3.4).

The number of times the calf vocalized and whether or not the attentiveness of the cow increased after these vocalizations was noted. Actions thought to indicate increased attentiveness included turning to face the calf, moving towards the calf, or orienting ears and face towards the calf. The length of time the calf was held by the stockperson and the time it took after the calf was released until the cow made physical contact (nose touch) with the calf was recorded as well. Other information gathered included number of times the cow vocalized, percent (%) of time the cow spent facing the calf, percent (%) of time the cow spent greater than 3m from the calf, and the initial distance between cow and calf.

Table 3.3 Guidelines for the subjective protection score given to the stockperson

Stockperson Score	Description of Protection Score
1	Cow is kept away from the calf using physical means such as slaps, tapping with handling stick, etc more than once
2	Cow is kept away from calf using body position
3	Protector does not attempt to keep the cow away from her calf

Table 3.4 Guidelines for the subjective score given to the cow while processing her calf (Adapted from Buddenberg et al., 1986)

Cow Score	Description of Cow Score
1	Cow made negative contact with stockperson (e.g. butting) or threatened to make negative contact (e.g. pawed at the ground)
2	Cow is interested in calf and procedures but does not threaten or attempt to remove stockperson
3	Cow exhibits very little or no interest in calf and procedures

3.2.5 Response to a Predator Model

After all calves had been processed on a particular day, one pair at a time was moved into a testing arena (Figure 3.1). In the center of the arena a smaller, pentagonal pen, measuring approximately 1m across was used to hold the calf during the testing period to ensure each calf was in the same location within the arena during testing. The calf pen was built of rigid, galvanized wire panelling which allowed the cow to see and smell the calf, but the calf's movement was restricted to this small area. After a one minute settling period, a solid panel at one end of the arena was slid open to allow the cow to see a stuffed coyote held behind a metal gate. After 30s, the coyote, which was mounted on a stiff board attached to a rope and pulley, was pulled approximately 45cm closer to the test arena, and therefore closer to the cow and calf. This was repeated three consecutive times until the coyote reached the metal gate. During the final movement period, the front of the coyote was lifted up and down 5-10cm to provide more movement of the coyote model. When the final 30s had passed, the solid panel was returned to its place on the gate, preventing the cow from seeing the coyote further. Solid panels were also used on either side of the coyote so that cows in adjoining pens would not see the coyote and affect the response of the cow in question. It also prevented untested cows from seeing the coyote model prior to their own test. The entire test within the arena was filmed.

For analysis, the cow's location in the test arena was recorded as being in one of 4 regions within the enclosure: far from predator (1), along the sides of the arena (not near calf or predator) (2), close to the calf (3), and close to the predator (4) (Figure 3.1). The cow's position was determined by her front feet and her position was determined for the baseline period and during exposure to the predator model. The change in her location from the baseline period to the predator test was also recorded. The more positive the change, the greater the percentage of time the cow spent in a higher ranked area of the arena. A negative change indicated the cow spent a lower percentage of time near in the higher ranked area when exposed to the predator compared to the baseline period. For example if a cow spent the baseline period along the sides of the arena and when exposed to the predator spent the entire period near her calf, her change would be recorded as a +1. The percentage of time that the cow spent facing the coyote was also recorded, as well as time to approach the predator (recorded as time remaining in test; cows that did not approach the predator were given a zero). The number of threats the cow made towards the

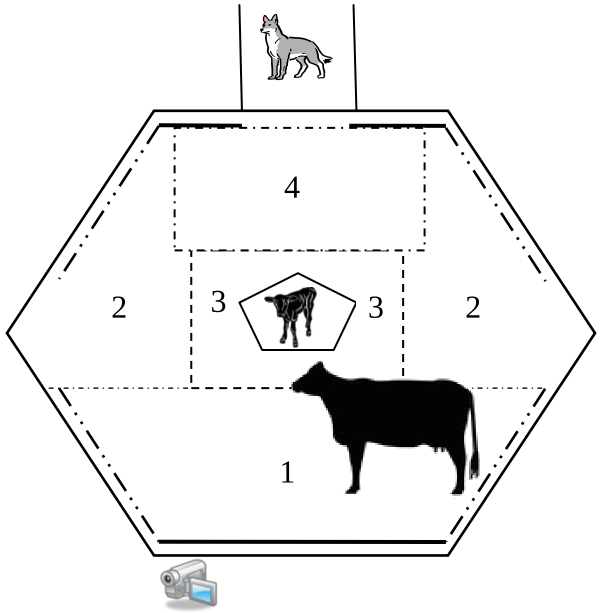

Figure 3.1 Diagram of the arena where the predator test was performed

predator was also recorded in year 2 (i.e. paws, head threats, charge). After the solid panel was replaced to hide the predator, the cow was let out into a larger pen while her calf was kept in the small central pen. The cow's behaviour when she exited the arena was filmed in the second year of observations as well.

In the second year, the coyote was replaced by a live dog because the response by the cows and heifers in year 1 was weak. The dog was kept on a leash and made to advance towards the gate following the same path and same timing of its advances as was used for the coyote model. Three different dogs (medium-large breeds) were used.

3.2.6 Immunoglobulin Transfer Test

A 5ml blood sample was taken from the jugular vein of the calf after the cow was removed from the test arena. The blood was spun using a centrifuge for 15 minutes at 1400 rpm and the serum was tested for total proteins using a temperature compensated hand-held refractometer to provide a measure of immunoglobulin transfer from the dam to her calf.

3.3 Statistical Analysis

Data were analysed using SPSS software (SPSS Inc., 2010, v. 18.0.2) and R (R Core Development Team, 2009), using the 'mvpart' package (v. 2.10.1). Nonparametric data were log transformed when possible. When transformations did not improve the normality of the data set, the original variables were used. Year 1 and year 2 were analysed separately, as some cows were culled after year one, and replacement heifers were added into the sample population in year 2.

A cut off point of 40 seconds was applied to the exit speeds of the cows in both years and before breeding. Whether or not another cow(s) was visible during a cow's exit from the chute in the pre-calving tests was recorded to see if this affected her exit speed. These variables were not found to be significantly correlated to exit speed in year 1, or during the pre-breeding tests ($p>0.05$) and were dropped from further analysis. There was a significant correlation between whether or not a cow was visible and exit speed in year 2 (Kendall tau-b=-.160, $p=0.014$) and therefore, this variable was retained in the analysis.

The duration of both the baseline of the predator test and exposure to the predator were also examined as covariates using Pearson or Kendall tau-b correlations. Neither duration was significantly correlated to variables in the predator test during the first year ($p>0.05$), and were dropped from the analysis. In year 2, baseline duration was again not significantly correlated to baseline variables ($p>0.05$) however the duration of predator exposure was significantly correlated to the cow's location during the predator test and the % of time spent watching the predator (Kendall tau-b=-.123, p=0.025; Kendall tau-b=-.121, p=0.026 respectively). Using partial correlations, controlling for duration of exposure was not found to affect any other relationships within the predator test and was removed from further analysis.

3.3.1 Principal Component Analysis

A principal component analysis (PCA) was performed on pre-calving variables (year 1 and year 2), tagging variables (year 1 and year 2) and pre-breeding variables. An oblique rotation was used to allow correlation between components. The Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) was used to determine whether the correlation matrices were suitable for PCA, with a minimum value of 0.5 required to continue analysis (Field, 2005). Kaiser's rule of retaining components with eigenvalues greater than one was used to determine the number of factors to retain in the analysis. Variables with high loadings of greater than an absolute value of 0.40 were interpreted in that component, however loadings greater than 0.35 were considered (Field, 2005).

The predator tests were not analysed using a PCA due to the low number of variables.

3.3.2 Multivariate Analysis

Following the PCA, multivariate analysis was used to analyse the relationships between pre-calving temperament components and maternal behaviour during tagging and during the predator test. A multivariate regression tree (MRT) was the method used for cluster analysis. MRT is a hierarchical method of constrained clustering and selects division points from the classification variables in order to minimise the within group variation (De'ath 2002). MRT does not assume any particular form of relationship between temperament and maternal behaviour and, therefore, is highly flexible. The splitting of the data at each node is done independently of other nodes, and as such emphasizes the local structure and interactions. For each node, a variance parameter indicates the amount of the remaining variance that is examined by the split. Our MRT analysis used Euclidean distances as distance measures. Models were selected by cross-validation using the 1-SE rule to select the tree size. The MRTs were performed in R 2.10.1 (R Development Core Team, 2009), using the 'mvpart' package (v. 2.10.1).

3.3.3 Repeated Measures ANOVA

A repeated measure ANOVA was used to analyse the consistencies in the cattle's responses from year to year, as well as from the pre-breeding tests to the pre-calving tests in year

2. Measurements were compared for animals that were included in the respective tests for each year. Where significant year effects were found, univariate analysis was performed to determine which variables varied from year to year.

3.4 Results

3.4.1 Descriptive Statistics

Frequency distributions for body condition scores, subjective temperament scores and total serum protein can be found in Appendix A. In year 1, subjective scores given in the chute before calving ranged from 1 to 4 (Table 3.5), while in year 2 subjective scores ranged from 1 to 3 (Table 3.7). Body condition scores were slightly higher in year 2 than year 1 and exit speed were slightly slower. Average calf birth weight and average total serum protein was higher in year 2 than year 1 as well (Table 3.8 and Table 3.6). Weaning weight was only available for year 1. Although correlation was allowed between components due to the use of an oblique rotation, correlations between components were low. Correlation coefficients can be found for each component analysis in Appendix A.

3.4.2 PCA

3.4.2.1 Pre-calving Year 1

Eighteen variables from year 1 were reduced to four components to account for 66.5% of the variance. One variable, contact REACH, was removed from the analysis due to a low MSA value. Component 1 had eight variables with strong loadings and one variable with partial loading (Table 3.9). This component accounted for 27.8% of the variance, and was labelled "Struggle". The measures that loaded on this component included the standard deviation and minimum force recorded by the strain gauge from each period while the animal was in the headgate. These loadings indicate that the animals which had the largest minimums had small standard deviations, likely because they did not struggle and stood calmly in the headgate. Component 2 accounted for 22.8% of the variance and was labelled "Push Out". This component was comprised of three variables from the baseline period as well the average and maximum from STAND and REACH (**Error! Reference source not found.**). Component 3 accounted for noticeably less variance at 9.9% and included the variables measuring the cow's body condition and size. This component was named "Cow Characteristics". Component 4 contained high loadings from contact STAND

Table 3.5 Descriptive statistics for variables recorded before calving in year 1.

Variable	Minimum	Maximum	Mean	Std Error of Mean
Body Condition Score	2.25	4.25	3.23	0.03
Subjective Temperament Chute Score	1	4	1.74	0.06
Exit Speed (secs to travel 4.29m)	1.34	40.00	7.59	0.57

Table 3.6 Descriptive statistics for production variables in year 1.

Variable	Minimum	Maximum	Mean	Std Error of Mean
Birth Weight (kg)	25.85	56.70	40.30	0.42
205 day Adjusted Weaning Weight (kg)	115.18	401.36	253.46	2.92
Total Serum Protein (g/dl)	4.50	10.10	6.74	0.06

Table 3.7 Descriptive statistics for variables recorded before calving in year 2.

Variable	Minimum	Maximum	Mean	Std Error of Mean
Body Condition Score	2.50	5.00	3.51	0.04
Subjective Temperament Chute Score	1.00	3.00	1.59	0.050
Exit Speed (sec to travel 4.29m)	1.85	40.00	9.83	0.62

Table 3.8 Descriptive statistics for production variables in year 2.

Variable	Minimum	Maximum	Mean	Std Error of Mean
Birth Weight (kg)	27.22	56.25	41.34	0.48
Total Serum Protein (g/dl)	4.80	9.30	6.88	.07

Table 3.9 Component loadings for pre-calving temperament tests in year 1 (n=191)

	Component			
	1	2	3	4
Component Name	"Struggle"	"Push Out"	"Cow Characteristics"	"Reaction to Handling"
% of Variance Explained	27.8	22.8	9.9	6.0
Eigenvalues	5.0	4.1	1.8	1.1
Cow Weight	-.002	.106	**.872**	.003
Body Condition Score	-.274	-.014	**.596**	-.143
Parity	.149	-.015	**.751**	.050
Subjective Temperament Score	**-.392**	**.374**	-.282	-.343
Contact STAND	-.207	.071	-.213	**.797**
Exit Speed	.251	-.053	.238	**.439**
Baseline Mean	.264	**.752**	-.007	-.095
Baseline Standard Deviation	**-.555**	**.384**	-.170	**-.353**
Baseline Maximum	-.182	**.659**	-.130	-.299
Baseline Minimum	**.572**	.240	.176	.122
STAND Mean	**.544**	**.587**	.154	-.117
STAND Standard Deviation	**-.753**	.374	-.022	-.117
STAND Maximum	.044	**.732**	.122	-.241
STAND Minimum	**.797**	.126	.193	-.226
REACH Mean	**.527**	**.660**	.001	.167
REACH Standard Deviation	**-.861**	.199	.216	.013
REACH Maximum	-.219	**.841**	.083	.305
REACH Minimum	**.787**	.322	-.092	-.039

*Cumulative variance explained by 4 components: 66.5%. Components extracted using principal component analysis.

**Variables were measured before calving in year 1. Exertion force mean, maximum, minimum and standard deviation were measured during three periods. Baseline period was a 10 second period where the cow's baseline exertion force was measured. STAND was a 10 second period where a person stood in front of the animal. REACH was a 10 second period where the person reached their hand out and held it approximately 2 cm off the animal's forehead. 'Contact STAND' was recorded in the STAND period. This variable recorded the type (or lack of) contact that the cow made with the person. If the animal tossed her head or butted the hand of the person, 'negative contact' was recorded. If the animal sniffed the person, 'positive contact' was recorded. If the animal did not make either type of contact with the person, 'no contact' was recorded.

and exit speed and partial negative loading from the baseline standard deviation. This component, accounting for 6.0% of the variance was named “Reaction to Handling”.

3.4.2.2 Post-calving Year 1

When performing the PCA of cow maternal behaviour measured during calf processing in year 1, the number of times a previous calf vocalised was removed from the PCA analysis because of a MSA less than 0.5. Five components were then identified from fourteen variables using Keiser’s rule. The components accounted for 65.9% of the variance (Table 3.10). Measures that loaded highly on Component 1 include those related to the distance from the cow to the calf and the percentage of time the cow spent facing her calf. The weighting of the variables indicates that animals which spent less time further than 3m from their calf took less time to reunite withtheir calf and spent more time facing their calf during processing. These animals were also further from their calf when it was caught by the stockperson, and this component was thus named “Distance to Calf”. The loadings for this variable indicate that a high “Distance to Calf” value depicts that the cow spent a higher amount of time facing her calf, less time far from her calf, was closer to calf when it was caught by the stockperson and reunited with the calf quickly. Component 2, named “Calf Characteristics” had high loadings from the sex and birth weight of the calf, indicating that male calves were heavier and were also held longer by the stockperson (males were castrated and thus had an extra procedure done). Component 3 had very high loading from the number of times the calf vocalized and the cow’s response to those vocalizations, and was named “Vocalizations”. The cow’s subjective score, the level of protection given by the stockperson and the number of times the cow vocalised loaded highly on component 4, resulting in the name “Cow’s Threat”. This component indicates that cows which were scored as more aggressive also received a higher level of protective intervention from the guarding stockperson. These cows also vocalized more. Component 5, labelled “Tagging Characteristics” was comprised of who was handling the calf, the age of the calf and the length of time the calf was held by the stockperson.

3.4.2.3 Pre-calving Year 2

Data from year 2 were again analysed using a PCA. Seventeen variables were reduced to six components to account for 74.5% of the total variance (Table 3.11). Cow weight, whether or not a cow was visible exiting the chute and STAND maximum were removed due to low MSA

Table 3.10 Component loadings for tests conducted at calf processing in year 1 (n=182)

	Component				
	1	2	3	4	5
Component Name	"Distance to Calf"	"Calf Characteristics"	"Vocalizations"	"Cow's Threat"	"Tagging Characteristics"
% of Variance Explained	22.7	15.7	11.5	8.7	7.3
Eigenvalues	3.2	2.2	1.6	1.2	1.0
Age of Calf at Tagging	-.175	.041	.009	-.022	**.605**
Sex of Calf	.151	**-.905**	.081	-.001	-.095
Birth Weight	.229	**.772**	.059	.080	.036
Calf Vocalizations	-.067	.042	**.817**	-.082	.050
Holding Time	-.056	**.584**	.027	-.103	**-.406**
Time Spent Facing Calf	**.715**	-.021	-.024	-.113	.099
Time Spent >3m from Calf	**-.881**	-.141	.030	-.034	-.026
Cow Maternal Score	.024	-.082	-.130	**.902**	.154
Initial Distance	**-.750**	.087	-.009	-.130	.050
Time to Reunite with Calf	**-.760**	-.020	-.003	.170	.088
Cow Vocalizations	.131	.270	.253	**-.484**	-.045
Responsive to Calf's Vocals	.004	-.084	**.902**	.087	.029
People Handling Calf	.220	-.018	.067	.011	**.813**
Level of Protection	-.001	.009	-.152	**.729**	.208

*Cumulative variance explained by 5 components: 65.9%. Components extracted using a principal components analysis.

** Variables measured at calf processing in year 1. Maternal score was a subjective score given to the cow regarding her response to her calf being handled by the stockpersons, with aggressive scored as 1, interested scored as 2 and indifferent scoring a 3. The level of protection that the stockperson afforded towards the cow while the calf was being handled was also subjectively scored, with physical contact made scored as a 1, body position to keep the cow away scored a 2 and no effort to keep the cow away scored a 3.

Table 3.11 Component loadings for pre-calving temperament tests in year 2 (n=155)

	Component					
	1	2	3	4	5	6
Component Name	"Push Out to Person"	"Baseline"	"Reach Response"	"Initial Response"	"Cow Characteristics-2"	"Stand Response"
% of Variance Explained	27.0	17.8	8.7	8.0	6.7	6.3
Eigenvalues	4.6	3.0	1.5	1.4	1.1	1.1
Body Condition Score	.011	-.245	.103	-.021	**.886**	-.007
Parity	.246	-.143	.121	-.104	**-.563**	-.215
Subjective Score	-.189	**.832**	.037	.036	-.053	-.065
Contact STAND	.068	-.099	-.064	.094	.011	**.808**
Contact REACH	.149	-.121	**.669**	-.014	-.309	.152
Exit Speed	-.211	-.219	.040	.114	**-.427**	.038
Baseline Mean	.157	.268	-.020	**.886**	-.028	.078
Baseline Standard Deviation	.117	**.889**	.010	-.173	.041	.102
Baseline Maximum	.042	**.892**	.076	.176	-.012	-.031
Baseline Minimum	-.145	**-.536**	.044	**.745**	-.021	-.083
STAND Mean	**.645**	.104	-.119	**.363**	.042	-.262
STAND Standard Deviation	-.063	**.350**	.164	.031	.094	**.578**
STAND Minimum	.198	.034	-.140	.246	.020	**-.660**
REACH Mean Struggle	**.870**	-.067	-.249	.101	-.084	.037
REACH Standard Deviation	.040	.327	**.757**	.025	.249	.012
REACH Maximum	**.909**	-.033	.212	-.076	.047	-.039
REACH Minimum	**.370**	-.092	**-.717**	.036	-.253	.045

*Cumulative variance explained by 6 components extracted using a principal component analysis: 74.5%.
** Variables were measured before calving in year 2. Exertion force mean, maximum, minimum and standard deviation were measured during three periods. Baseline period was a 10 second period where the cow's baseline exertion force was measured. STAND was a 10 second period where a person stood in front of the animal. REACH was a 10 second period where the person reached their hand out and held it approximately 2 cm off the animal's forehead. 'Contact STAND' and 'Contact REACH' were recorded in the two periods respectively. These variables recorded the type (or lack of) contact that the cow made with the person. If the animal tossed her head or butted the hand of the person, 'negative contact' was recorded. If the animal sniffed the person, 'positive contact' was recorded. If the animal did not make either type of contact with the person, 'no contact' was recorded.

Values. Component 1 (27.0% of variance), was named “Push Out to Person” and included the mean, maximum and minimum during REACH, as well as mean STAND. Variables which loaded on Component 2 included standard deviation, maximum and minimum from the baseline period and subjective score, so this component was named “Baseline”. Component 3 included the contact made, standard deviation and minimum for REACH and Component 6 included these same measurements for STAND. These components were thus named “Reach Response” and “Stand Response” respectively. Component 4 contained high loadings from baseline mean and minimum and was named “Initial Response”. Component 5 was named “Cow Characteristics-2” as it had high loading from body condition score, negative loading from parity, as well as negative loading from exit speed. Exit speed is most likely associated with this component because first parity animals exited faster.

3.4.2.4 Post-calving Year 2

Eleven variables were reduced to 4 components which represented 63.5% of the variance of the cow’s response to calf processing in year 2 (Table 3.12). Four variables were removed due to a low MSA: calf sex, people handling the calf, the level of protection and number of times a previous calf vocalized. Component 1, named “Attentive to Calf”, accounted for 24.0% of the variance and had high loadings from the time the cow spent facing the calf and the subjective maternal score. The number of times the cow vocalised as well as the time to reunite with the calf also loaded on this component. Component 2 accounted for 17.2% of the variance. This component had high loadings from the initial distance, time spent >3m from the calf, time to reunite with the calf and holding time. This component was named “Distance to Calf-2”. Component 3 consisted of high loadings from the number of times the calf vocalized and the cow’s response to the calf’s vocalizations, as well as the number of times the cow vocalized. This component accounted for 12.1% of the variance, and was labelled “Vocalizations-2”. Component 4, “Calf Characteristics-2” was comprised of the calf’s birth weight and age, as well as the length of time the calf was held.

3.4.2.5 Pre-breeding

A PCA was also performed on the variables collected before breeding of the replacement heifers. Exit speed, contact STAND and REACH standard deviation were removed due to low MSA values. This left fourteen variables to be analysed using the PCA. Five components were extracted and together accounted for 82.4% of the variance (Table 3.13). Component 1

Table 3.12 Component loadings for tests conducted at calf processing in year 2 (n=150)

	Component			
	1	2	3	4
Component Names	"Attentive to Calf"	"Distance to Calf-2"	"Vocalizations-2"	"Calf Characteristics-2"
% of Variance Explained	24.0	17.2	12.1	10.2
Eigenvalues	2.6	1.9	1.3	1.1
Age of Calf at Tagging	-.142	-.131	.015	**-.594**
Calf Birth Weight	-.004	-.278	.025	**.783**
Holding time	**-.437**	**.512**	-.030	**.413**
Number of Calf Vocalizations	.141	-.086	**.856**	.057
Time Spent Facing Calf	**-.757**	-.090	-.105	.005
Time Spent >3m from Calf	**.377**	**.690**	-.044	-.108
Responds to Calf's Vocalisations	-.084	.050	**.804**	-.101
Cow Maternal Score	**.765**	.025	-.052	.249
Initial Distance	-.112	**.840**	-.008	-.016
Time to Reunite with Calf	**.442**	**.572**	.116	-.080
Cow Vocalizations	**-.598**	.091	**.439**	.204

*Cumulative variance explained by 4 components: 63.5%. Components extracted using a principal components analysis.

** Variables measured at calf processing in year 2. Maternal score was a subjective score given to the cow regarding her response to her calf being handled by the stockpersons, with aggressive scored as 1, interested scored as a 2 and indifferent scoring a 3.

Table 3.13 Component loadings for test conducted on replacement heifers before breeding (n=43)

	Component				
	1	2	3	4	5
Component Name	"Pull Back Response to Person"	"Push Out Response to Person"	"Baseline"	"Push Out"	"Weight and Reach"
% of Variance Explained	37.8	14.1	12.2	9.4	9.0
Eigenvalues	5.3	2.0	1.7	1.3	1.3
Heifer Weight	-.224	-.053	-.079	**.371**	**.773**
Subjective Score	-.032	-.283	**.682**	.131	-.159
Contact REACH	-.099	.007	.206	.228	**-.690**
Baseline Mean	.114	.042	**-.553**	**.652**	-.019
Baseline Standard Deviation	-.123	-.005	**.896**	.176	-.051
Baseline Maximum	.153	-.044	.107	**.856**	.106
Baseline Minimum	.159	-.062	**-.800**	.293	.098
STAND Mean	**.712**	.340	-.125	.251	-.209
STAND Standard Deviation	**-.982**	.155	.091	.072	.063
STAND Maximum	-.039	**.388**	.030	**.721**	-.086
STAND Minimum	**.809**	.004	-.174	.205	.096
REACH Mean	.167	**.856**	-.016	.144	.100
REACH Maximum	-.286	**.796**	-.325	.066	-.216
REACH Minimum	**.422**	**.553**	.305	-.110	**.460**

*Cumulative variance explained by 5 components: 82.5%. Components extracted using a principal components analysis.

** Variables were measured before breeding the replacement heifers in year 2. Exertion force mean, maximum, minimum and standard deviation were measured during three periods. Baseline period was a 10 second period where the cow's baseline exertion force was measured. STAND was a 10 second period where a person stood in front of the animal. REACH was a 10 second period where the person reached their hand out and held it approximately 2 cm off the animal's forehead. 'Contact REACH' was recorded in this period. This variable recorded the type (or lack of) contact that the cow made with the person. If the animal tossed her head or butted the hand of the person, 'negative contact' was recorded. If the animal sniffed the person, 'positive contact' was recorded. If the animal did not make either type of contact with the person, 'no contact' was recorded.

accounted for 37.8% of the variance, Component 2 for 14.1%, Component 3 for 12.2%, Component 4 accounted for 9.4% of the variance and Component 5 for 9.0%. Component 1 was labelled “Pull Back Response to Person” as it contained high loadings from the minimum from the STAND and REACH periods and STAND mean. STAND standard deviation loaded negatively on this component as well. Component 2 contained loadings from the maximum, average and minimum REACH, and partial loading from STAND max and was thus named “Push Out Response to Person”. Component 3 contained baseline strain variables as well as subjective score and was named “Baseline”. Component 4 contained high loading from baseline and STAND maximum and baseline mean and was named “Push Out”. Component 5, named “Weight and Reach”, contained high positive loading from cow weight and high negative loading from Contact REACH.

3.4.3 Multiple Regression Trees

Regression trees generated using multivariate analysis can be found in Appendix A.

3.4.3.1 Year 1

The MRT analysis for year 1 (n=164) resulted in a one node tree with two final groups. This tree explained 4.7% of the variance in the maternal behaviour. The variable which explained the most variance was “Cow Characteristics”. The graphs indicated that this node splits cattle based on “Distance to Calf” and “Calf Characteristics”. The graphs indicated that cattle which are primiparous, weigh less and have a lower body condition score have a lower “Distance to Calf”, indicating that they spend less time near their calf and less time watching it during processing. These cattle also have calves which weigh less and are more often female, and are held for processing for a shorter time.

3.4.3.2 Year 2

The MRT analysis for year 2 (n=109) resulted in a one node tree which explained 2.7% of the variance in the maternal behaviour and separated cattle into two final groups. The temperament variable which explained the most variance was “Cow Characteristics-2”. The bar plots indicated that this node split animals based on the people which handled the calf and “Attentive to Calf”. The distance for the cow to turn when she was let out of the predator test arena was also important in this split. The bar plots indicated that mulitparous cows with lower body condition scores and higher exit speeds watch their calf more, vocalise more, have a lower maternal score (more aggressive) and decreased time to reunite with their calf. These cows also turn around in a shorter distance when they are let out of the arena.

3.4.3.3 Pre-breeding

A single node tree with two final groups was also generated by a MRT analysis for the pre-breeding tests on the heifers (n=31). The variable which split the data was “Weight and Reach”, accounting for 7.0% of the variance. The bar plots indicated that the cattle are split using whether or not the animal returned to the arena while the blood sample was being taken from her calf. Heifers with low weight before breeding that made negative contact with the person during REACH did not return to the arena after the predator test and their calves had slightly higher total serum protein than others.

3.4.3.4 Tagging and Predator Tests

3.4.3.4.1 Year 1

A multiple regression tree (Figure 3.2) was also generated using the tagging test variables as predictors for the response to the predator in order to examine relationships between cows' responses to people and predators (n=164). For the data from year 1, a two node tree was generated with three final groups. The tree explained 5.7% of the variance. The variable which explained the most variance for the initial split was “Calf Characteristics” (var_{split}= 0.026). The variable which was used to split the cattle in the first node was the change in location in the arena from the baseline to the exposure to the predator.

The second node was also split using “Calf Characteristics”, but in this case weaning weight of the calf was the deciding factor (var_{split}= 0.033). The first split indicates that cows with calves that are smaller and female have a more positive change in their location when they are exposed to the predator (indicating they spend more time near their calf and the predator). The second split shows that male calves which are larger at birth have a larger weaning weight.

3.4.3.4.2 Year 2

In year 2 (n=109), the MRT analysis of post-calving and predator test variables produced a one node tree with two final groups and explained 3.6% of the variance. The tree was split on “Distance to Calf-2”, and the split was based on the whether or not the cow returned to arena after she was released and her calf remained to have a blood sample taken. The tree indicated that cattle with a large “Distance to Calf-2” did not return to the arena once they were released.

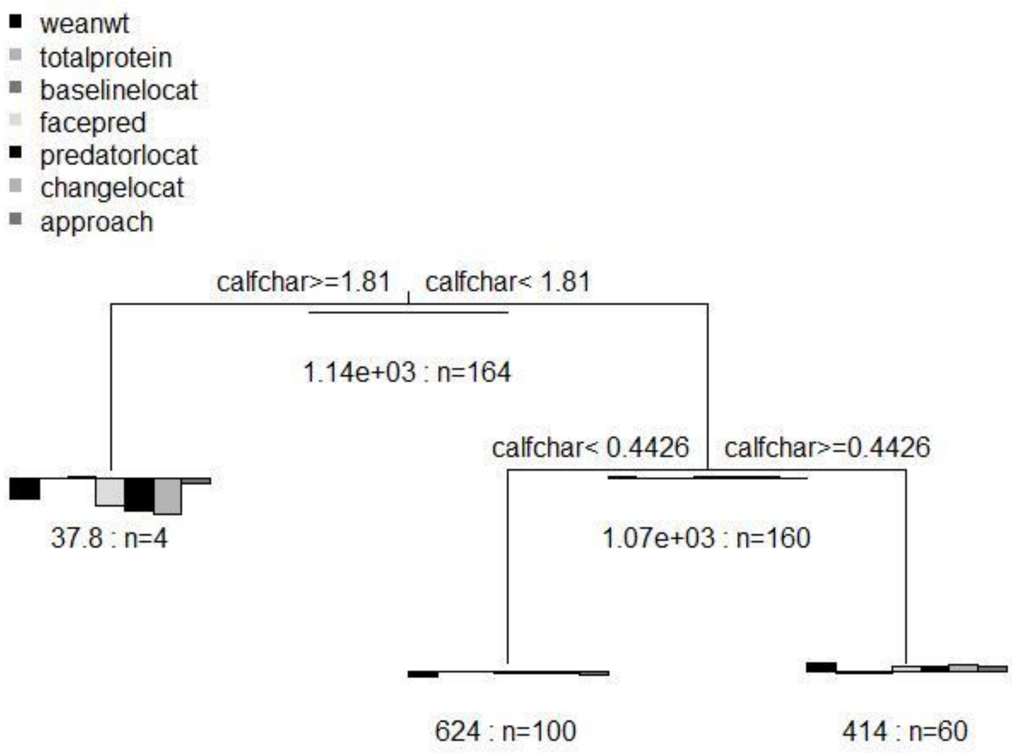

Figure 3.2 Diagram of a multiple regression tree for year 1, predicting variations in a cow's response to a predator and production variables from variations in response to a stockperson handling her calf. Bar plots show the standardized multivariate predator response means at each node. The cyclical shading (black, grey, dark grey, light grey) indicate the predator response and production variables and run from left to right on the bar plots. This tree explains 5.7% of the variance in the maternal behaviour. Euclidean distances were used for splitting the nodes. The depth of the tree following each split is proportional to the variance explained for each split.

3.4.4 Year to Year Comparisons

Year to year comparisons were done using a Repeated Measures MANOVA. These comparisons did not include all cattle in the test population but only those which were tested in year 1 and year 2, or pre-breeding and year 2.

3.4.4.1 Pre-calving Tests

There was an overall significance of year on pre-calving tests ($F_{(10,90)}$=101.26, p<.001, Wilks' Lambda=0.082). Variables which were significantly different were baseline standard deviation, STAND mean, STAND standard deviation, REACH standard deviation, exit speed, and contact REACH. Variables that were not significantly different between years were subjective score, baseline mean, REACH mean and contact STAND.

3.4.4.2 Pre-breeding to Pre-calving

There was also significant differences between the pre-breeding temperament tests and the pre-calving tests on heifers tested in year 2 ($F_{(10,30)}$=16.52, p<.001, Wilks' Lambda=0.082). Using univariate analyses, significant differences between years were found for baseline mean, baseline standard deviation, STAND mean, STAND standard deviation, REACH mean, REACH standard deviation, exit speed, and contact during STAND. Subjective score and contact during REACH did not differ.

3.4.4.3 Total protein

The mean total protein in year 1 was 6.8 and in year 2 was 7.0. Repeated measure ANOVA shows that there was a significant effect of year on total protein levels ($F_{(1,94)}$=4.78, p=.031, Wilks' Lambda=0.952).

3.4.4.4 Tagging test

Tagging tests differed significantly from year to year as well ($F_{(8,89)}$=45.38, p<.001, Wilks' Lambda=0.197). Significant differences between years occurred in time spent facing the calf, cow vocalizations, cow maternal score, time to reunite with calf and level of protection given by stockperson. No difference was seen in the time spent further than 3m from calf, response to calf's vocalizations and initial distance to calf.

3.4.4.5 Predator test

There was also a significant difference between year 1 and year 2 for the predator test ($F_{(5,87)}$=963.59, p<.001, Wilks' Lambda= 0.018) however different stimuli were used in year 2 than year 1. Significant differences were found in the time spent watching the predator, location during exposure to predator, change in location from baseline to exposure and time to approach predator. These are most likely indicative of the increased response to live stimuli and should be interpreted as such.

3.5 Discussion

3.5.1 Removal of Animals Based on Temperament

Aggressive cows are not uncommon as found by Sandelin et al. (2005). Of cows that were given a maternal behaviour score in the case study, 6.3% were considered "very aggressive, fought the handler to protect calf". These cattle can easily cause injuries to the people who are working with them. Breed has been found to impact the maternal behaviour (Le Neindre, 1989; Sandelin et al., 2005; Hoppe et al., 2008) and temperament (Morris et al., 1994) of cattle. Unfortunately in this study, the breed of many animals was not known as many of the animals had recently been purchased from outside sources and as such was not able to be analysed.

Raising replacements is an expensive element in livestock production at approximately \$1000/bred heifer, while the price of a cull cow is approximately \$575/cow (Manitoba Agriculture, Food and Rural Initiatives, 2009) so there is often reluctance to cull an animal once it is in the herd, based on temperament alone. This reluctance may partially be due to the lack of an opportune time to cull cows from the herd if they continue to rebreed, as they are always raising a calf or pregnant with the next calf.

Also, because these cows are generally only aggressive for up to a week after parturition, there is likely some tolerance of this behaviour. It is possible that the stockperson's memory of the extent of the aggression has faded by the time that the animal could be culled. Perhaps the best way to avoid having these cows in a herd would be to cull them before they were bred for the first time. To do this would require having some method of identifying future maternal traits of a female prior to first mating.

Using temperament to predict maternal behaviour could be a useful technique for use in selection of replacement breeding stock and could reduce problems such as mis-mothering and eliminate dangerously aggressive animals. While it is known that calmer animals have better weight gains (Voisinet et al., 1997) a link to maternal behaviour in cattle has not been investigated.

Research in swine has shown that gilts that savage their piglets are more likely to show "shy" behaviour in a pre-farrowing human approach test, and gilts that are highly aggressive towards people after farrowing are more likely to show “bold” behaviour in the same human approach test (Marchant Forde, 2002). This suggests that there may be underlying characteristics that relate to temperament both before and after parturition.

3.5.2 Temperament Measurements and Maternal Behaviour

Strain gauges, subjective scores and exit speeds have been used extensively to assess the temperament of cattle (Burrow et al., 1988; Grandin, 1993; Schwartzkopf-Genswein, et al., 1997). The PCA of pre-calving tests showed agreement between these measurements as well. While multiple regression trees were able to split the data, the variance explained by the trees was minimal. Temperament variables do not appear to predict maternal behaviour particularly well in cattle, which is contrary to the results found in swine (Marchant Forde, 2002; Janczak et al., 2003) sheep (Kilgour, 1998) and rhesus macaques (Maestripieri, 1993). The variables which are most predictive in each instance do provide some insight into the relationship between temperament and maternal behaviour. Unfortunately, cows that were highly aggressive towards humans after calving were not able to be tested using these measurements due to safety concerns. If a test was developed which included these animals, more revealing results may be found.

The multiple regression trees were able to split cattle based on their weight, parity and body condition score in year 1 and in year 2. “Distance to Calf” was an important variable in the splits in year 1. “Cow Characteristics” were likely related to the “Distance to Calf” in year 1 because many of the primiparous animals were noticeably fearful of people. Also, the inexperience and reduced neuroendocrine response of primiparous animals may mean that their fear of humans overshadowed their desire to protect their calf (Dwyer and Lawrence, 2000). The distance from the cow to her calf is likely affected by the animal’s fear of people because animals which are more fearful of humans do not approach the stockperson when their calf is being handled. This behaviour may in fact indicate the animal’s fear of people and not her maternal behaviour.

While it may appear that animals which spend less time near their calf when it is being handled are better because the risk of injury to stockpersons is smaller, animals that are extremely fearful of people can cause injury to themselves, other animals, or people, if they attempt to escape confinement. These animals can also be more difficult to handle and have lower average daily gains (Voisinet et al., 1997). Ideally, a cow would be attentive to her calf without being a danger to people, as well as not being overly fearful of stockpersons.

In year 2, the cows were divided based on the people handling the calf and how attentive the cow was to her calf. Cattle which were multiparous; had a lower body condition score and exited the chute faster, appeared to be more attentive to their calf when it was handled. In year 1, multiparous cattle spent more time close to their calf and more time watching their calf. Cows that have a high body condition score have the ability to mobilize more energy and thus can increase their maternal care, which can be physically demanding. None of the cows in this study scored less than a 2.25 body condition score on a 1 to 5 scale, which may not be low enough to see a great impact on the maternal care exhibited.

3.5.3 Response to Humans and Predators

If a cow must be protective of her calf towards people to ensure that she protects it from predators, it would be expected that the cows requiring higher levels of protection from the stockperson would have a greater response to the predator. However, this does not appear to be true. In year 1, the calves' characteristics were related to the cows' responses to the predator, but the cows' responses to handling of their calves were not identified as an important predictor of her response to a predator. In year 2, a live dog replaced a model coyote, and as such the responses towards the predator were stronger. This was also seen by Hansen et al (2001), where a live dog stimulated a greater response in sheep compared to taxidermist models of wild predators, and Kluever et al. (2009) where cattle reacted differently when exposed to different types of predator mounts. In our case the only variables that were related from the post-calving tagging test to the predator test were those describing the cows' exit from the arena and not their responses to the predator. It appears from our analysis there is little relationship between a cow's reaction to a human and to a predator. Hansen et al. (2001) also found that sheep behaved differently when exposed to a man compared to either predator models or a man with a live dog. Despite this observable ability to detect the difference between types of predators and humans, our results should be interpreted with some caution, as this type of test has not been validated. It is possible that the behaviour of the dog and stance of the coyote were not perceived as threatening by all cows equally and as such did not accurately and reliably measure their response to a predator.

3.5.4 Production Variables

Total serum protein was somewhat important in the split for the pre-breeding responses. The few cattle that had a low weight before breeding, and also made negative contact with the person during REACH, also had higher total serum protein levels, however as this was only two animals, further exploration of this relationship may be required. In year 2, total protein was involved in the division of cattle but had a smaller impact than other variables. The split does indicate that multiparous cattle with a lower body condition score and a slower exit speed have calves with a higher total protein level. These relationships were not noticeable in year one. Temperament may not be a consistent predictor of total protein because many other aspects can impact serum protein levels such as the quantity and quality of colostrum ingested which can be influenced by the age and breed of the dam (Weaver et al., 2000). Also, the management at the research farm was such that the stockpersons ensured that each calf received colostrum. This interference may have masked poor maternal behaviour that might otherwise have resulted in reduced colostrum consumption by the calf.

Weaning weight was only available for year 1, and was not well described by temperament traits. However weaning weight appears to be lower in those cattle which were primiparous, had a lower body condition score, and exited the chute slower.

3.5.5 Comparisons from Year to Year

The tests performed after calving in year 1 and year 2 involved different calves, however as the dam was the test subject, the tests were not considered independent. These results should be interpreted with some caution however, as environmental or other differences could impact the cow's response from one year to the next.

There was a significant difference found between years in all tests but not all variables. Cattle may have had a lower response to the pre-calving procedures in the chute in year 2 because of their experience in year 1. Subjective score did not change with year, and appears to be a consistent measure of temperament.

Maternal behaviour does appear to vary from year to year however distance to calf is consistent from year to year. It is possible that distance behaviours are related more to the temperament of the animal than the animal's maternal behaviour, as stated by Dwyer and Lawrence (1998), and as temperament is generally considered to be consistent across time and situations, this could be responsible for the consistency seen with this behaviour.

3.5.6 Conclusions

While multiple regression trees were produced for each set of tests, the amount of variance explained by these trees was small. Temperament variables such as exit speed may impact certain aspects of maternal behaviour and the response of a cow to a person, particularly the distance the cow keeps from the stockperson handling her calf, but there appears to be other factors which are more influential, such as parity. The response of a cow to a stockperson handling her calf is not necessarily indicative of her response towards a predator or her performance as a mother.

Hormone levels are one area where minimal research has been performed in cattle, and likely has a large impact on the maternal behaviour of that animal. Oxytocin is vital in establishing a mother-offspring bond (Kendrick, 2000), and it is probable that low levels of oxytocin are in part responsible for poor maternal care.

4 SURVEY OF BEEF PRODUCERS

4.1 Introduction

Appropriate maternal care is important because calves must receive adequate colostrum within the first 24 hours or they have a higher risk of sickness and death as well as lower weight gains (Wittum and Perino, 1995; Dewell et al., 2006). It is therefore advantageous to cattle producers to have cows that nurse and do not abandon their calves. Natural and artificial selection for maternal care should also lead to cattle that defend their calf against predators in order to ensure their survival. As calving becomes more extensive and the amount of contact between cattle and stockpeople decreases, cattle may become more defensive of their calf towards people if they are perceived as predators (Le Neindre et al., 1998; Turner and Lawrence, 2007). The incidence of mis-mothering and aggressive behaviours are unknown in commercial beef herds, and as such the goal of this producer survey was to determine the incidence of mis-mothering and aggression at calving, as well as gather information about producers' attitudes toward these behaviours and characteristics of the animals or herd that may contribute to these problem behaviours.

Injuries and occasionally deaths are inflicted by cows at calving. In Canada from 1990 to 2004, 23 people were killed by cows (Canadian Agriculture Injury Surveillance Program, 2008). Working with animals is also the most common cause of agriculture injury that results in hospitalization (18.7%); with cows and bulls causing most injuries in men (Canadian Agriculture Injury Surveillance Program, 2003). Cattle related injuries are most common from March to May, and are not surprisingly, often related to calving or recently calved cows (Canadian Agriculture Injury Surveillance Program, 2003). One example of a death reported in an agricultural injury surveillance program in 4 US states from 2003 to 2008 involved a cow becoming aggressive when a person was removing the cow's dead, newborn calf from the pen (Centers for Disease Control and Prevention, 2009).

Cattle that are overly protective of their newborn calf can be aggressive towards people and pose a potential health threat to their human handlers. Conversely, cattle that show a lack of interest in their calves are also a problem for beef producers. The incidence of these behaviours, their causes and tolerance that producers have for them is unknown. For example, overly aggressive animals may be kept in the herd because producers assume they are better mothers. Producers with herds that suffer predation may have a greater risk of creating or tolerating overly aggressive cows at calving. Cattle on the other end of the spectrum, that mis-mother or abandon their calves, may be the result of other contributing factors such as dystocia or an interruption in the bonding process.

4.2 Methodology

The survey was conducted at two Saskatchewan cattle shows in November 2009: Saskatoon Fall Fair and Canadian Western Agribition in Regina. Surveys were conducted as either oral (in a face to face interview format) or handed to respondents to fill out on their own and handed back when finished. Respondents were determined by approaching people and asking if they were cattle producers and if so, to perform a survey about cattle behaviour at calving. If they declined at this point, it was recorded as a 'no' to measure response rate. When a respondent was willing to answer questions directly in an interview fashion, then an effort was made by the surveyor to avoid biasing the participant towards a particular answer by simply reading the choices available for each question.

There are limitations to the sample, as the survey was conducted at cattle shows. It is likely that purebred producers were over-represented, and the producers that attend livestock shows may tend to be different than producers not attending the show, however, this was one of the least expensive and best ways available to reach many people in a short period of time. Talking to people face to face is also much more likely to generate participation than a telephone or mail out survey (Yu and Cooper, 1983).

The survey was also distributed at the 2010 Saskatchewan Beef and Forage Symposium in Saskatoon, SK in January 2010. The response rate was unable to be determined because it is not known how many producers were present.

Questions asked included the number of dangerous cattle and the number that mis-mothered their calf, as well as whether these animals were culled. Other questions included the reasons that animals may show aggression towards people or mis-mother their calf, whether these behaviours change over subsequent calvings and whether these animals are noticeably different from the herd before they calve. The level of production that a producer requires to keep these cows was also asked. The producers' history of injuries, as well as current predation problems and demographics were also included. A copy of the survey can be found in Appendix B.

4.2.1 Data Analysis

Three different surveys were distributed. The questions were identical, but the order of the choices available in certain questions was switched in the various surveys to ensure the order of options did not bias the respondent. In some cases, while producers were asked to select only one option, they instead circled more than one choice, resulting in some discrepancies in percentages.

Data was analysed using Microsoft Excel® 2007 and SPSS software (v. 18.0.2, 2010). Descriptive statistics, including mean, range, sum and percentages were determined. Correlations between certain responses were investigated using Pearson correlation coefficients.

4.3 Results

While many results are shown, further results can be found in Appendix C.

4.3.1 Demographics

The response rate for this particular survey was very high, with 92% of producers approached participating in the survey and only 14 people refusing to participate. Of the 168 respondents, 133 were male and 33 were female. In 2 cases, a man and woman (presumably husband and wife) answered the survey together. The majority of respondents (41%) were ≤ 35 years of age, 23% were 46-55 years old, 19% were 35-45 and 17% were ≥ 56.

The majority of respondents raised both purebred and commercial cattle (51%), while 21% raised only commercial cattle and 29% raised only purebred cattle. The vast majority of survey participants (70%) raised more than one breed of cattle. Angus cattle were the largest single breed represented with 13% of producers raising only Angus cattle.

When asked what level of contact the respondent had with their newborn calves, only 8% of the producers answered "zero contact with calves within their first 2 days of life", while 87% of the respondents tagged their calves within this period.

4.3.1.1 Years Experience in the Cattle Industry

The question posed to determine the years of experience a respondent had with cattle was likely interpreted differently between individuals. Some may have interpreted the question as the number of years they themselves have owned cattle; others may have interpreted the question as the amount of time they have been around cattle/industry. Based on responses given it was realized the question may have been poorly written. As a result some assumptions and manipulation of the results were made.

If the respondent gave “life” as the response to this question, they were given the lowest number of years in their age category (e.g. for the 36-45 category, they would be given 36 years experience). For the 35 and younger category, if life was the response, they were given 20 years of experience, as this was the average experience among the respondents in the ≤ 35 age category who gave a numerical response. The median years of experience in the cattle industry was determined to be 25 years, with a range of 4 to 65.

4.3.2 Incidence and Tolerance of Dangerous Cattle

Over all, producers indicated that within their herds 6% of cows with a newborn calf were believed to be capable of hurting them if they were given the chance and 76% of farms had at least one cow that was considered dangerous (

Table 4.1). On average, 4% of the females in a herd were considered dangerous at calving. Based on the number of cattle owned by respondents it translated to an average number of dangerous cattle in a herd to be 11.5, with a range of 0 to 308 dangerous animals in a herd.

The questionnaire was designed to determine the producers' tolerance for dangerous cattle by asking them the level of performance required by such a cow in order for her to remain in the herd. When asked the level of production (Figure 4.1) a cow must attain in order to stay in the herd if she was considered dangerous, the majority of producers (32%) stated they would keep the cow only if she raised an above average calf. While 27% of producers would cull the cow regardless of her performance, another 20% would cull the cow if she was aggressive more than one calving season. A further 16% would keep the cow if she raised an average or better calf, which left only 8% that would keep the cow regardless of performance.

4.3.3 Incidence and Tolerance of Mis-mothering

The majority of the producers (60%) culled cattle that mis-mothered (abandoned or failed to care for their calf). This resulted in 62% of cattle that mis-mother their calf being culled. The incidence of mis-mothering was only 1%, despite 56% of farms experiencing at least one incident of mis-mothering in the 2009 calving season. Mis-mothering incidence was much higher in primiparous females compared to multiparous females, as seen in Table 4.2

Table 4.1 Incidence and culling of dangerous cattle

	Dangerous cattle	Dangerous first calf heifers	Dangerous mature cows	How many dangerous will you cull
Number of Farms	125	35	120	67
Total number of cows	1913	215	1610	250
Percentage of Farms	76.2%	21.6%	73.2%	53.6%
Percentage of Animals	5.7%	4.0%	5.7%	13.1%

Table 4.2.

Table 4.1 Incidence and culling of dangerous cattle

	Dangerous cattle	Dangerous first calf heifers	Dangerous mature cows	How many dangerous will you cull
Number of Farms	125	35	120	67
Total number of cows	1913	215	1610	250
Percentage of Farms	76.2%	21.6%	73.2%	53.6%
Percentage of Animals	5.7%	4.0%	5.7%	13.1%

Table 4.2 Incidence and culling of mis-mothers

	How many cattle mis-mothered	Mis-mothered 1st calf heifers	Mis-mothered cows	How many mis-mothers will you cull
Number of Farms	94	67	64	56
Total number of cows	480	272	196	295
Percentage of Farms	56.3%	40.1%	38.6%	59.6%
Percentage of Cows	1.4%	5.0%	0.7%	61.5%

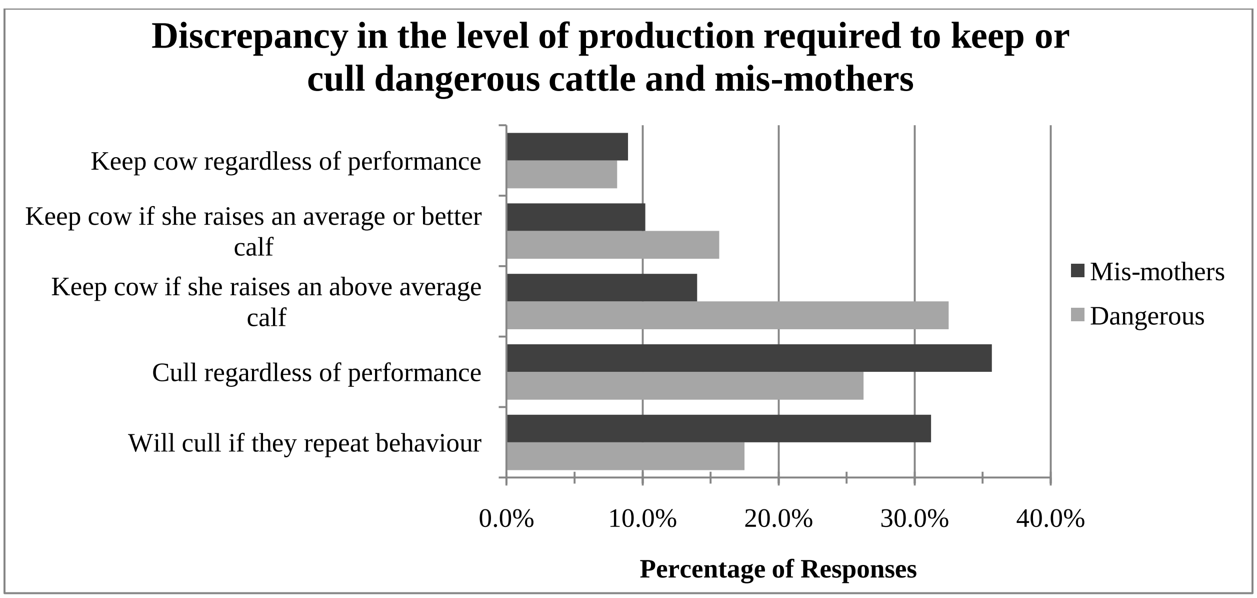

Figure 4.1 Level of performance a producer required to keep or cull dangerous cattle and cattle that mis-mother their calf

When asked the level of production (Figure 4.1) a cow must attain in order to stay in the herd if she mis-mothered her calf, the majority of producers (36%) culled these regardless of their performance. A further 31% culled a cow if she mis-mothered her calf in more than one parity. Only 14% of the producers indicated they would keep a 'mis-mothering cow' if she raised an above average calf and 10% of producers would keep mis-mothering cows if they raised an average or better calf. Only 9% of producers indicated they would keep such a cow regardless of performance.

4.3.4 Changes in Dangerous Cattle and Cattle that Mis-mother

When asked to select the most accurate out of five options about the change seen in dangerous cattle over subsequent calvings, 36% of producers agreed that they did not notice a change in these cows across parities. However, 22% stated that dangerous mothers get more dangerous over subsequent calvings, though 20% do not give the cow a second chance. Only 19% of producers claim that cattle become less dangerous in subsequent calvings.

Producers were given the same five options to select from with respect to change over subsequent calvings for mis-mothers. The majority of producers (38%) declared that cattle that mis-mother their calf are not given a second chance. Also, 29% of producers stated that they believe cattle will mis-mother less in subsequent calvings, while 15% did not see a change in subsequent calvings.

4.3.5 Predictors of Dangerous Cattle and Mis-mothers

Producers were asked to select the most accurate answer out of five options with respect to noticeable differences seen in dangerous cattle in the month before they calve. A resounding 63% stated that dangerous cattle were not noticeably different than the rest of the herd in the month before calving. However, 25% did notice these cows as more nervous than the rest of the herd, while only 3% observed that dangerous cattle were more docile than the majority of the herd.

The majority of producers (73%) also did not notice differences between cows that mis-mothered their calf in the month before calving. Slightly more producers noticed these cattle as being more nervous than the rest of the herd (8%) when compared to more docile (4%).

4.3.6 Reasons that Cows Are Dangerous

Producers were given a list of possible reasons that cattle are dangerous at calving and asked to select what they believed to be the three most important reasons. 'Family line' was selected most often, at 69% (Figure 4.2). ‘Hormones present at calving’ was selected 52% of the time and breed 51% of the time. In addition 49% of respondents selected ‘Interrupted by another cow or person’ as the reason for cows displaying dangerous behaviour at calving time. All other available options were selected by 15% or less of respondents.

4.3.7 Reasons that Cows Mis-mother their Calf

When given a similar list of potential reasons why a cow might mis-mother her calf, respondents selected ‘General lack of interest by the mother’ and ‘Interrupted by another cow or person’ most frequently (both at 54%) (Figure 4.3). ‘First calf heifer’ and ‘Twins’ were also considered important reasons, and were selected by 52% and 44% of respondents, respectively. ‘C-section/hard pull’ was selected fifth often, at 30%. Genetics was not considered to be as important in contributing to mis-mothering, as ‘Family line’ was selected 18% of the time and ‘Breed’ was selected by only 14% of respondents.

4.3.8 Injuries

A total of 62 producers (37% of respondents) had at some point been intentionally injured by a cow with a newborn calf. Of these, 11% visited the doctor for the injury. Of those injured, only 53% culled the cow that had intentionally injured them.

4.3.9 Predation

Roughly 37% of producers experienced predation of their cattle in the past 5 years. Losses ranged from one calf over the past five years to 85 lost over the past 5 years. The average number of calves lost over 5 years was 3.3 calves based on the total number of respondents; but not all respondents experienced predation. Among those producers that experienced predation the average was 8.5 calves lost over the last 5 year period. Coyotes were known or believed to be solely responsible for predation in the majority of cases (72%).

4.3.10 Correlations

Certain variables were expected to impact others, for example the number of dangerous cattle or those that mis-mothered may be related to the size of the herd. Correlations were performed on such variables in order to determine these relationships and improve understanding of the data. A summary of correlations can be seen in Table 4.3.

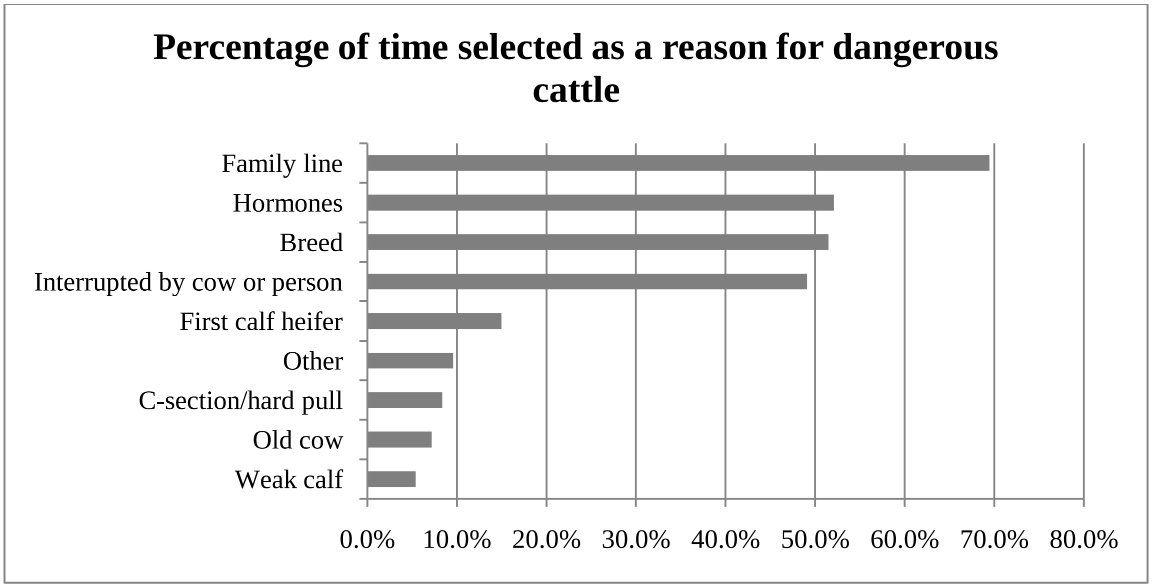

Figure 4.2 Reasons producers perceived as causing dangerous cattle at calving

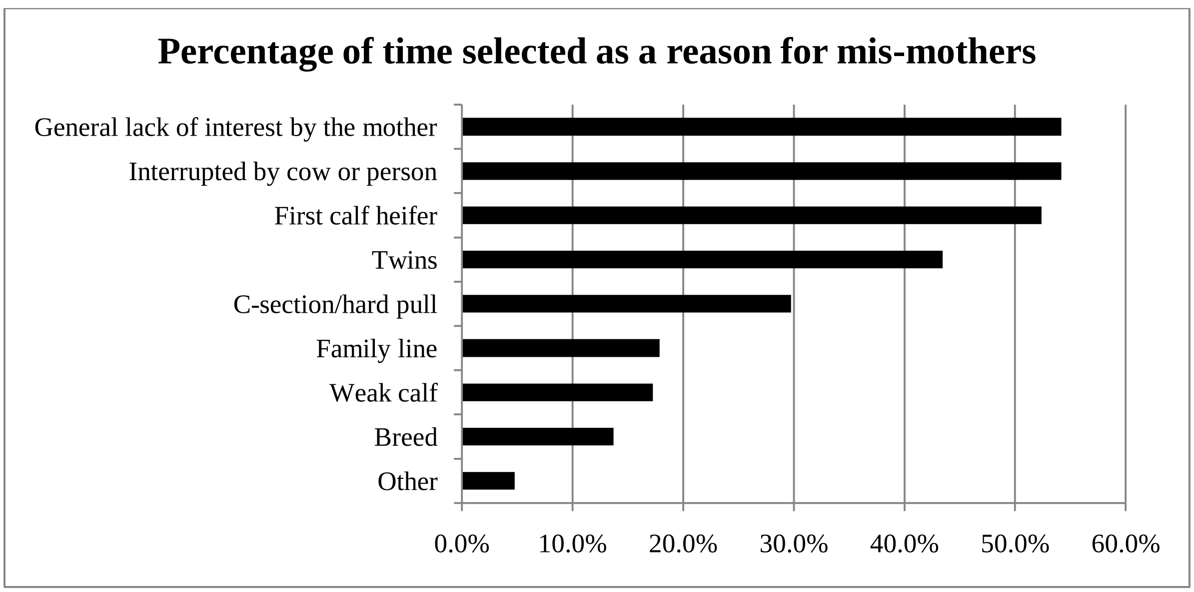

Figure 4.3 Reasons producers perceive as causing cattle to mis-mother their calf

Table 4.3 Correlation coefficients found between various survey responses

	Percent of cattle that are dangerous†	Percent of cattle that mis-mother†	Has the producer ever been injured by a recently calved cow	Level of performance required to keep dangerous cattle	Level of performance required to keep mis-mothers
Level of contact producer has with calves in the first 2 days	**-.412****	-.013	.097	**.351****	**.268****
Number of calves killed by predators in past 5 years†	-.011	.173	.123	-.042	.088
Age category of producer	**.177***	-.072	-.018	.155	.031
Years of experience with cattle††	.072	-.120	.087	.011	.073
Level of performance required to keep dangerous cattle	**-.324****	-.011	-.133	--	**.315****
Level of performance required to keep mis-mothers	**-.210***	.033	.098	**.315****	**--**
Has the producer ever been injured by a recently calved cow	-.020	.193	**--**	-.133	.098

Bolded values express significant findings
†Controlled for total number of cattle
†† Controlled for age category
*Significant at the p≤ .05 level
**Significant at the p≤ .001 level

4.3.10.1 Incidence

Herd size was controlled for in the following correlations, as total number of cattle was correlated to the number of dangerous cattle in a herd as well as the number of cows that mis-mother their calves.

The percent of dangerous cattle in a herd was negatively correlated to the amount of contact the producer had with calves in the first 2 days after birth ($r = -.412$, $p<0.001$). It was not correlated to the number of calves killed by predators ($r = -.011$, $p>.05$) or the years of experience of the producer ($r = .098$, $p>.05$) when the herd size and age of producer was taken into account.

The percent of cows in a herd that mis-mother their calf was not correlated to the level of contact that a producer had with calves in the first two days after birth ($r = -.013$, $p>.05$), but was correlated to the number of calves killed by predators, however this correlation was very low ($r = .173$, $p=.03$). The percent of cow that mis-mothered was also not correlated to the age ($r = -.072$) or experience of the producer (when age is accounted for; $r = -.079$), (all ps>.05).

4.3.10.2 Level of Performance

The level of performance required to keep a cow that is dangerous was negatively related to the percent of the herd that was dangerous ($r = -.324$, $p \leq .001$), but the level of performance required to keep a mis-mother was not correlated to the percent of a herd that mis-mother their calf ($r = .033$, $p>.05$). The level of performance required to keep a cow that was dangerous or that mis-mothered her calf was also not correlated to the number of calves killed by predators, $r = -.007$ and $r = .111$ respectively, $p>.05$).

The level of performance that a producer required to keep a cow that was dangerous or that mis-mothered her calf was related to the level of contact that the producer had with calves within the first 2 days after birth ($r = .351$, $p<.001$ and $r = .268$, $p=.001$ respectively).

4.3.10.3 Age of Respondent

The age category of the respondent was correlated to the percent of animals in a herd that were dangerous, although the correlation was low ($r = .177$, $p = .023$), but age was not related to the percent of animals that mis-mothered ($r = -.072$, $p>.05$). The age of the respondent was also not related to the level of performance required to keep a dangerous cow or a cow that mis-mothered her calf ($r = .155$ and $r = .031$ respectively, ps>.05).

4.3.10.4 Years of Experience

The years of experience the producer had with cattle (controlled for age category of the producer) was not correlated to the percent of cattle in the herd that were dangerous ($r= .072$) or the percent that mis-mothered their calf ($r= -.120$) when the herd size was held constant (all $ps>.05$). The years of experience was also not correlated to the level of performance required to keep dangerous cattle or mis-mothers ($r= .011$ and $r= .073$ respectively, $ps>.05$).

4.4 Discussion

4.4.1 Demographics

Surveys conducted in person (as was done in this survey) could be suspect to unintentional biases, particularly if some responses are socially undesirable (Wiseman, 1972). However, we were careful to avoid leading the producer to select specific answers and we drafted three separate surveys with identical answers arranged in different orders to help avoid bias. The questions which were asked were not socially sensitive questions and very few answers could be considered more socially acceptable or unacceptable than others.

The location that the surveys were conducted (at livestock shows) may have influenced the type of producers which were questioned. For example, it is likely that the demographics over-represent young purebred cattle producers whom, for whatever reason, maybe more likely to attend cattle shows. We know that the age distribution of farm operators is quite different than the age demographics seen in our survey, with nearly 91% of farm operators in Canada being over the age of 35 (Statistics Canada, 2007), compared to 59% of our respondents. Purebred breeders are likely over-represented in the survey, due to the location where the surveys were conducted. Of nearly 76,000 beef cattle producers in Canada, approximately 10,000 (13%) raise purebred cattle, which is obviously much lower than the percentage of our respondents which raise purebred cattle (Canadian Beef Breeds Council, 2007; Statistics Canada, 2007). The sampling frame in this particular survey was also unknown, which makes extrapolation of the results beyond these particular producers unreliable.

These discrepancies may undermine the ability to make sweeping statements about the incidence and tolerance of these behaviours over the entire cattle industry. In certain cases it is also possible that estimates instead of exact numbers were given by the producers and therefore the incidences reported may lack complete accuracy. The results should be interpreted with these discrepancies in mind.

The response rate was much higher than would be expected in a traditional survey, with only 14 people refusing to participate. This response rate was likely influenced by the method of surveying, as surveyors did not ask all producers present, and could have unintentionally approached people who appeared easy to talk to. The response rate may have also been lower than recorded because on occasion one person out of a group would agree to participate, while the other(s) would seem interested and then would leave while the first person was completing the survey. It was not known if these people would have declined participation or simply did not want to interrupt the surveying process.

Because the large majority of producers (70% in our survey) raised more than one breed of beef cattle, breed differences could not be determined. Gender differences were also not investigated as the number of female respondents was low (approximately 25%).

4.4.2 Incidence and Tolerance

The incidence of dangerous cattle was found to be 6% of all cattle owned by the respondents, which may be considered low, however these cattle appeared on 76% of farms, indicating that they are in fact widespread among beef producers. The maximum number of dangerous cattle in a particular herd was 308, however many farms did not have any cattle that were considered dangerous; suggesting that the average number per farm reported here may have been artificially skewed by these extremes. The incidence of dangerous first calf heifers was much lower than that of mature cows. This could be due to increasing maternal experience causing cattle to become more protective of their calf with increasing parity, as was seen by Hoppe et al. (2008). This increase is also likely in part due to the low culling rate of dangerous cattle. As only 13% of dangerous cattle in the present survey were culled for that reason, it is probable that many first calf heifers that are dangerous are remaining in the herd and therefore the number of dangerous mature cows is allowed to accumulate. It is also possible that cattle removed from one herd due to aggression towards people are sold into another herd and are not removed from the total cattle population. Producers may be selling these animals as bred cattle or with a calf at their side, and potential buyers may not be aware of their danger towards people.

The percentage of dangerous cattle in a herd was found to be negatively correlated with the level of contact that producers had with their calves in the first 2 days of calving; as the number of dangerous animals in a herd increases, the level of contact decreases. It is not known if producers that have dangerous cattle decrease their contact with the animals for this reason, or if producers that have little contact with the calves after birth have no need to remove dangerous animals or select against this behaviour, so the incidence becomes inflated.

A low positive correlation was found between the age of the producer and the percentage of dangerous cattle in a herd, however no correlation was found with years of experience and percentage of dangerous cattle in a herd.

There was a significant positive correlation (more likely to cull) between the level of performance a producer required to keep a dangerous cow and the level of contact that the producer had with newborn calves. This is understandable, as producers that handle their calves in greater amounts would be under greater risk of injury when dealing with aggressive cattle, and should therefore tolerate these animals less than those with little or no contact with newborn calves. Interestingly, a slight positive correlation is also seen between the level of contact with calves and the level of performance required to keep cattle that mis-mother. It could be that these producers are simply exerting greater selection on both extremes of maternal behaviour and do not consider performance to be of utmost importance.

The incidence of mis-mothering was lower than that of dangerous cattle. Mis-mothering was however still seen on 56% of farms. Mis-mothering appears to be much more prevalent in primiparous females. This was also found to occur in sheep, where inexperienced mothers were more likely to reject their lamb (Dwyer and Lawrence, 2000). This could in part be due to physiological reasons as well as neophobic reaction of the dam to the offspring. As 62% of cattle that mis-mother their calf are culled for that reason, it is likely that these animals are not accumulating in herds as is seen with dangerous cattle. This is another potential reason why the incidence of mis-mothering in mature cows was lower than that of primiparous cattle.

Producers' reduced tolerance for mis-mothering was visible in the level of production that they required of that animal in order to keep them in the herd as well. The majority of producers claimed they would cull cows that mis-mother their calves regardless of the cow's performance in raising a calf. Another large portion of producers would cull a cow that mis-mothered her calf a second time.

There was an obvious differential of acceptance of dangerous cattle and those that mis-mother their calf. While 33% of producers would keep a dangerous cow that raises an above average calf, only 14% of producers would allow a cow that mis-mothers her calf the same leniency. These results indicate that producers may be willing to cope with a dangerous cow for a short period after calving if that animal is an excellent producer. As profitability is derived from weight gains, it is important to have cattle that wean a high gaining calf and reluctance to cull these cows may be seen despite the other problems that are present. For some reason this was not true for animals that mis-mother their calf. This could be because these cattle require more time and labour to raise the calf and this is not easily forgotten by producers, whereas the danger a cow shows at calving may not require more work per se, other than to remember to stay away from her. It is also possible that producers put great value in mothering behaviour and some expect cattle that are dangerous towards people to be more protective of their calf in other situations (such as when confronted with the threat of predation).

Another reason for the differing tolerance levels could be that producers expect dangerous cattle to become less dangerous over subsequent parities. Conversely, this was not found to be the case. Greater than one third of producers admitted that dangerous cattle do not change and 22% stated that they in fact become more dangerous over subsequent calvings. On the other hand, nearly 30% of producers declared that cattle mis-mother less in subsequent calvings, and only 7% expected them to mis-mother more often. Thus, it is even more intriguing that producers cull more cattle that mis-mother their calf than cattle that would try to hurt them. It is possible that there is a cultural mindset among cattle producers where aggressive cattle are considered to be excellent mothers and are therefore desirable in the cow herd. Cattle which mis-mother their calf conversely may be thought of as being poor mothers who are aggravating for producers and are not worth the effort that it takes to ensure that they care for their calf. Cattle which mis-mother their calf could also be much more easily culled at calving if there is another suitable option for raising the calf such as a foster cow or selling the calf. Dangerous cattle would be less likely to be culled at this time because they are caring for a calf. If mis-mothering leads to the death of the calf, producers may consider this a reason to cull the cow as well.

4.4.3 Predictors of Dangerous Cattle and Mis-mothers

Producers were also asked if there was a temperament difference prior to calving in cattle that mis-mother their calf or are dangerous towards people. Producers spend great amounts of time with their cattle and have vast amounts of information about those animals, and may be able to offer some insight into consistent differences in animals that become problem mothers. Unfortunately, the majority of producers did not recognize consistent differences in cattle that mis-mothered their calf or became dangerous after calving in the month prior to calving. A slight difference was found in the percentage of producers that noticed that cattle were nervous. While 25% of producers claimed that dangerous cattle were more nervous than the majority of the herd before calving, only 8% of producers said the same thing about cattle that went on to mis-mother their calf. It is possible that cattle that are nervous around people (and perhaps less tame) have a greater potential to become dangerous than to mis-mother their calf, although this does not appear to hold true in all situations. This is contrary to results found in swine, where gilts which were dangerously aggressive towards the stockperson following farrowing had a lower heart rate and made more contact with a human during a human approach test (Marchant Forde, 2002). Cattle which are highly nervous may recognize people as predators and react accordingly, whereas cattle which are calmer may more accurately identify the differences between people and predators. The response to people before calving does not appear to be consistent in all animals that are dangerously aggressive or that mis-mother their calf however.

4.4.4 Reasons that Cows are Dangerous or Mis-mother their Calf

The top four reasons that producers selected as a potential cause of dangerous cattle were the family line, hormones, breed and being interrupted by another cow or person. The picture is not as clear for cattle that mis-mother their calf. A general lack of interest by the mother, interruption by another cow or person and first calf heifer were followed closely by cows with twins and cows experiencing a c-section or assisted delivery. Genetics was not considered an important influence of mis-mothering, but was identified by producers as contributing to the development of a dangerous cow. It is interesting to note that while many of the top reasons that producers selected as contributing to mis-mothers are situational factors and the reasons selected in regard to dangerous cattle are factors present within that individual animal, producers were more willing to keep a dangerous cow than a cow that mis-mothered her calf even though by their own admission they are potentially selecting for more dangerous cows since they believe genetics to be a factor. It is also surprising that dystocia and c-section were not selected more often as important reasons for mis-mothering, since these factors are known to increase mis-mothering (Stookey, 1997). The incidence of c-sections and dystocia, as reported by veterinarians, has declined recently (Jelinski, 2009) which may explain why producers did not select this reason more often.

4.4.5 Injuries

More than one third of respondents reported they had been injured by a cow at calving. It may be expected that producers that have been injured are more likely to have a high level of contact with newborn calves, however no correlation was found. There was also no correlation found between the number of dangerous cattle in a herd and whether a producer had been injured. This does not necessarily mean that dangerous cattle are not the animals causing injuries, more likely it depicts that a person does not need to have several dangerous animals in order to be injured, in may only take one dangerous animal over the entire career of a cattle producer to inflict an injury.

While monitoring of injuries is usually done using hospitalization records, we found that only 11% of those injured visited a doctor for the injury. This may indicate that many injuries are not severe enough to warrant medical attention. It also suggests that the 1279 injuries involving cattle (not including bulls) recorded by the Canadian Agricultural Injury Surveillance Program from 1990 to 2000 is most likely grossly underestimating the amount of injuries that are occurring due to cattle – even though not all the recorded injuries occurred at calving.

Once again producer's tolerance of dangerous cattle was evident in the rate of culling cattle that had inflicted injuries. Only 53% of producers that were injured by a cow at calving culled the offending cow despite the obvious risk that that animal posed. Producers often offered excuses for the animal in this case, stating that it was the person's fault or the circumstances which caused the cow to become aggressive. In some cases the producer would also not remove the animal from the herd because of her performance and productivity. One woman responded that her injury by a cow at calving cost her to miss an entire season of curling, but she was equally upset that her husband had not culled the cow.

4.4.6 Predation

Predation was a significant problem for some producers, with up to 85 calves being lost over the previous 5 years, and over all, producers lost an average of 3.3 calves per year. Among the 37% of producers that experienced predation over the past 5 years, the average number of calves lost was 8.5. Producers that suffered from predation may desire cows that are more protective of their calves in order to combat predation, or it could be thought that cows that are under pressure from predators are in turn more dangerous towards people when they have a calf. However, the number of calves killed by predators was not related to the percent of dangerous cattle and the relationship to the percent of cattle that mis-mothered was low. The number of calves killed by predators was also not related to the level of performance required to keep a cow that is dangerous or that mis-mothers her calf.

4.4.7 Conclusions

Producers exhibit a much higher tolerance of cattle that are dangerously aggressive than those that mis-mother their calf. This is likely related to the lower incidence of mis-mothering when compared to dangerous cattle, both in individual herds and in the population sampled. Producers attribute genetics as the major factor in the development of dangerous cattle, while mis-mothering is often attributed to situational factors. Injuries among producers are common, however the reaction of producers is not always to cull the animal, but often to blame themselves. The rate of predation is not related to the number of dangerous cattle in a herd, suggesting that dangerous cattle do not reduce predation of calves.

5 GENERAL SUMMARY AND CONCLUSIONS

Maternal behaviour is an important part of beef cattle production. Maternal studies to this point have focused mainly on using subjective measurements to analyse maternal behaviour, however these can be less reliable than objective measures. The relationships between the response of cattle to people and their reaction to predators have not been investigated prior to this study. The studies outlined in this thesis encapsulate potential ways to predict this behaviour, as well as the reaction that producers have towards certain behavioural extremes. Maternal behaviour is not necessarily easy to measure, and is often intertwined with the animal’s response to people. The first study, as described in Chapter 3, focused on using established temperament tests, as well as a novel test in the chute, to test the response to a person in close proximity of the animal. These measurements were then analysed with respect to variables obtained after calving which measured the animals’ responses to people handling their calf as well as to a predator.

Temperament of the dam has little impact on weaning weight of the calf or passive transfer of antibodies, as these variables are more likely related to management and other considerations such as breed or age of the dam. The response of a cow to people was also not indicative of her response to a predator. Cattle generally appeared to differentiate between a predator and a person, and did not need to show aggression towards a person in order to show protective behaviour towards a predator.

Chapter 4 of this study presented a survey of beef producers done in Saskatchewan. The results from this survey showed that cattle that were aggressive at calving were not uncommon and in many cases this behaviour was tolerated. Mis-mothering, conversely, was often not tolerated, which most likely related to the lower incidence of these cattle in beef herds. The survey also offered insight into potential causes for these behaviours and producers attributed aggression at calving mainly to genetics, while mis-mothering was often considered a situational problem.

The results of this study indicated that many measures of maternal behaviour are not related to the temperament of the animal. Certain variables such as amount of time the cow spends far from the calf during handling were related to temperament; however, this variable may indicate fearfulness of people more than poor maternal behaviour. It appears that a cow’s temperament is, in general, a poor predictor of her maternal behaviour.

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APPENDIX A

Table A.1 Frequency distribution of body condition scores taken before calving in year 1.

BCS	Frequency
1	0
2	5
2.5	19
3	95
3.5	31
4	41
4.5	0
5	0

*Scores are an average of body condition score given by two technicians.

Table A.2 Frequency distribution of subjective temperament chute score given before calving in year 1 (see Table 3.2 for definition of each score).

Subjective Temperament Score	Frequency
1	94
2	59
3	30
4	8
5	0

Table A.3 Frequency distribution of total serum protein levels from calves in year 1.

Total Serum Protein	Frequency
5.00	6
5.50	8
6.00	13
6.50	52
7.00	42
7.50	28
8.00	26
≥8.50	8

Table A.4 Frequency distribution of body condition scores taken before calving in year 2.

BCS	Frequency
1	0
2	0
2.5	5
3	31
3.5	63
4	55
4.5	8
5	4

*Scores are an average of body condition score given by two technicians.

Table A.5 Frequency distribution of subjective temperament chute score given before calving in year 2 (see Table 3.2 for definition of each score).

Subj Sc	Frequency
1	76
2	70
3	12
4	0
5	0

Table A.6 Frequency distribution of total serum protein levels from calves in year 2.

TSP	Frequency
5	1
5.5	9
6	16
6.5	31
7	36
7.5	22
8	22
≥8.5	17

Table A.7 Pre-calving year 1 component correlation matrix

Component	1	2	3	4
1	1.00	.047	.199	.180
2	.047	1.00	.057	-.216
3	.199	.057	1.00	.038
4	.180	-.216	.038	1.00

*Components extracted using principal component analysis; oblimin rotation method.

Table A.8 Pre-calving year 2 component correlation matrix

Component	1	2	3	4	5	6
1	1.00	.037	-.129	.114	-.122	-.236
2	.037	1.00	.140	-.046	.280	.093
3	-.129	.140	1.00	-.171	.045	.227
4	.114	-.046	-.171	1.00	-.099	-.114
5	-.122	.280	.045	-.099	1.00	.067
6	-.236	.093	.227	-.114	.067	1.00

*Components extracted using principal component analysis; oblimin rotation method.

Table A.9 Post-calving year 1 component correlation matrix

Component	1	2	3	4	5
1	1.00	.073	.076	-.159	-.019
2	.073	1.00	.152	-.179	-.172
3	.076	.152	1.00	-.230	-.036
4	-.159	-.179	-.230	1.00	.101
5	-.019	-.172	-.036	.101	1.00

*Components extracted using principal component analysis; oblimin rotation method.

Table A.10 Post-calving year 2 component correlation matrix

Component	1	2	3	4
1	1.00	.142	-.099	-.120
2	.142	1.00	.062	.080
3	-.099	.062	1.00	.061
4	-.120	.080	.061	1.00

*Components extracted using principal component analysis; oblimin rotation method.

Table A.11 Pre-breeding component correlation matrix

Component	1	2	3	4	5
1	1.000	.199	-.186	.106	.190
2	.199	1.000	-.204	.220	.054
3	-.186	-.204	1.000	-.157	-.117
4	.106	.220	-.157	1.000	.029
5	.190	.054	-.117	.029	1.000

*Components extracted using principal component analysis; oblimin rotation method.

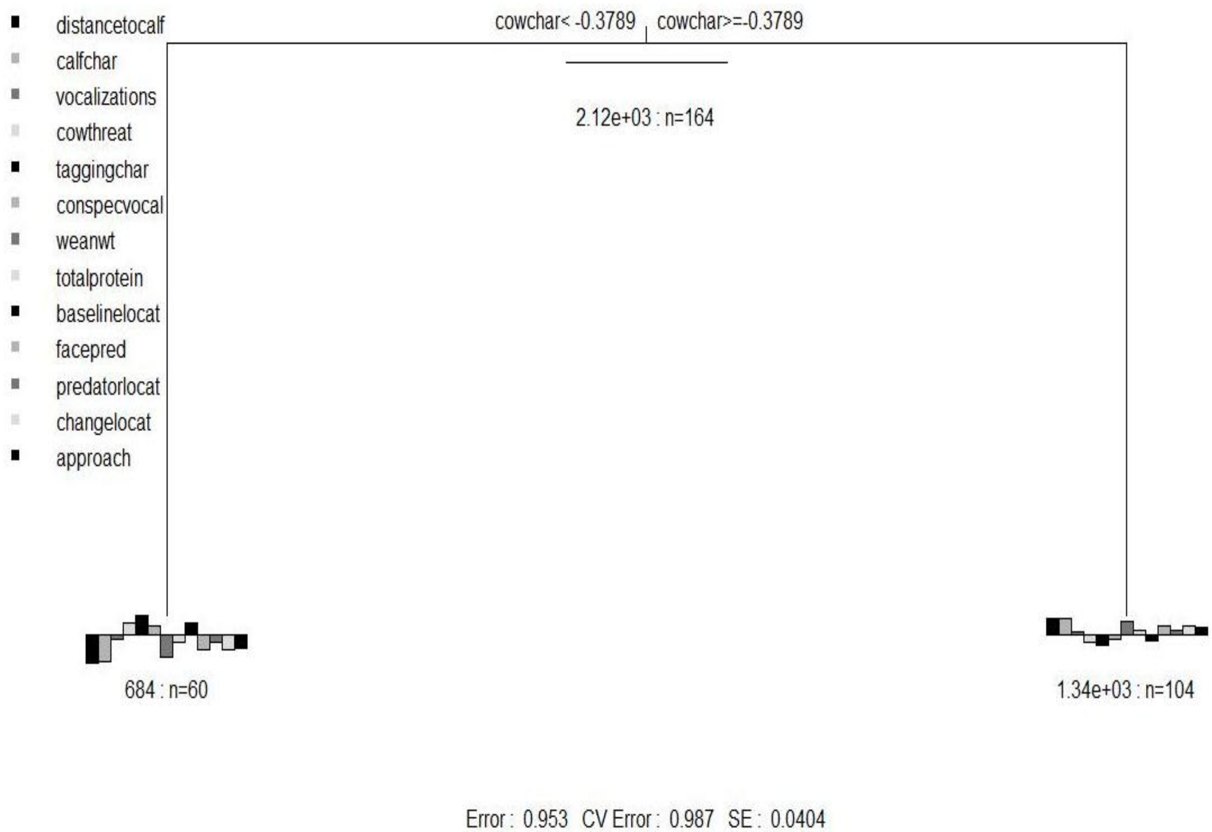

Figure A1 Diagram of a multiple regression tree for year 1predicting variations in maternal behaviour from variations in temperament in beef cattle. Barplots show the standardized multivariate maternal behaviour means at each node. The cyclical shading (black, grey, dark grey, light grey) indicate the maternal behaviour variables and run from left to right on the barplots. This tree explains 4.7% of the variance in the maternal behaviour. Euclidean distances were used for splitting. The depth of the tree following each split is proportional to the variance explained for each split.

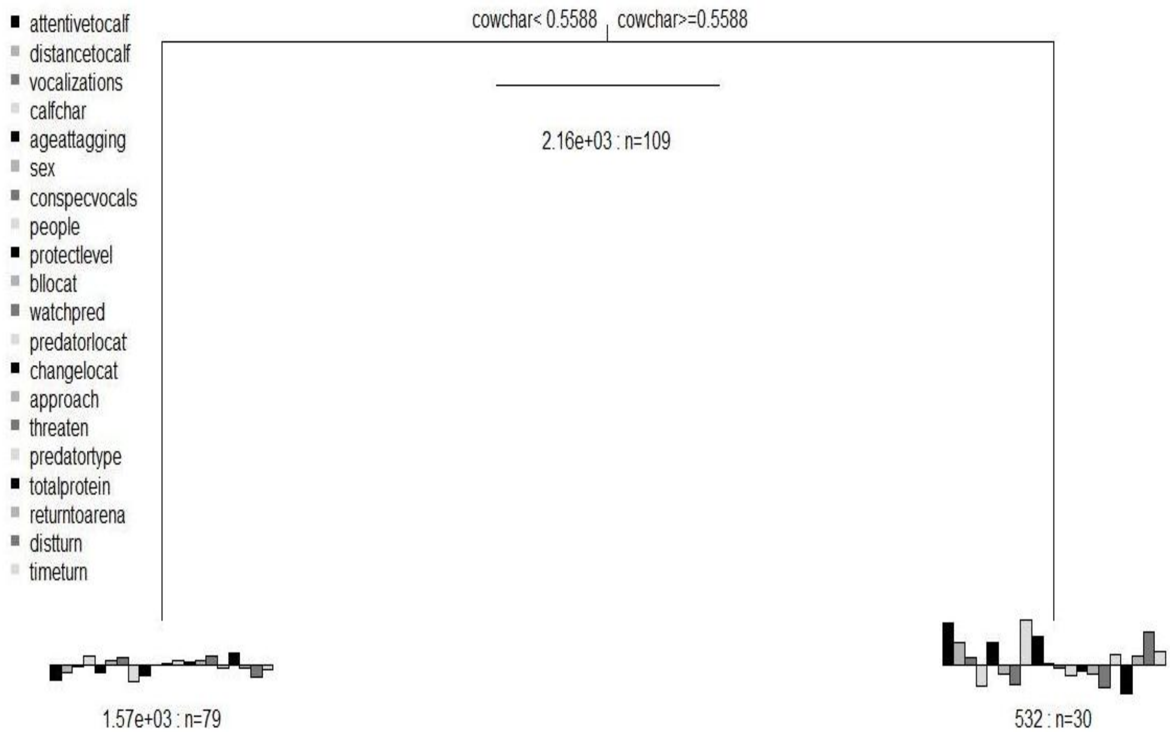

Figure A2 Diagram of a multiple regression tree for year 2 predicting variations in maternal behaviour from variations in temperament in beef cattle. Barplots show the standardized multivariate maternal behaviour means at each node. The cyclical shading (black, grey, dark grey, light grey) indicate the maternal behaviour variables and run from left to right on the barplots. This tree explains 2.7% of the variance in the maternal behaviour. Euclidean distances were used for splitting. The depth of the tree following each split is proportional to the variance explained for each split.

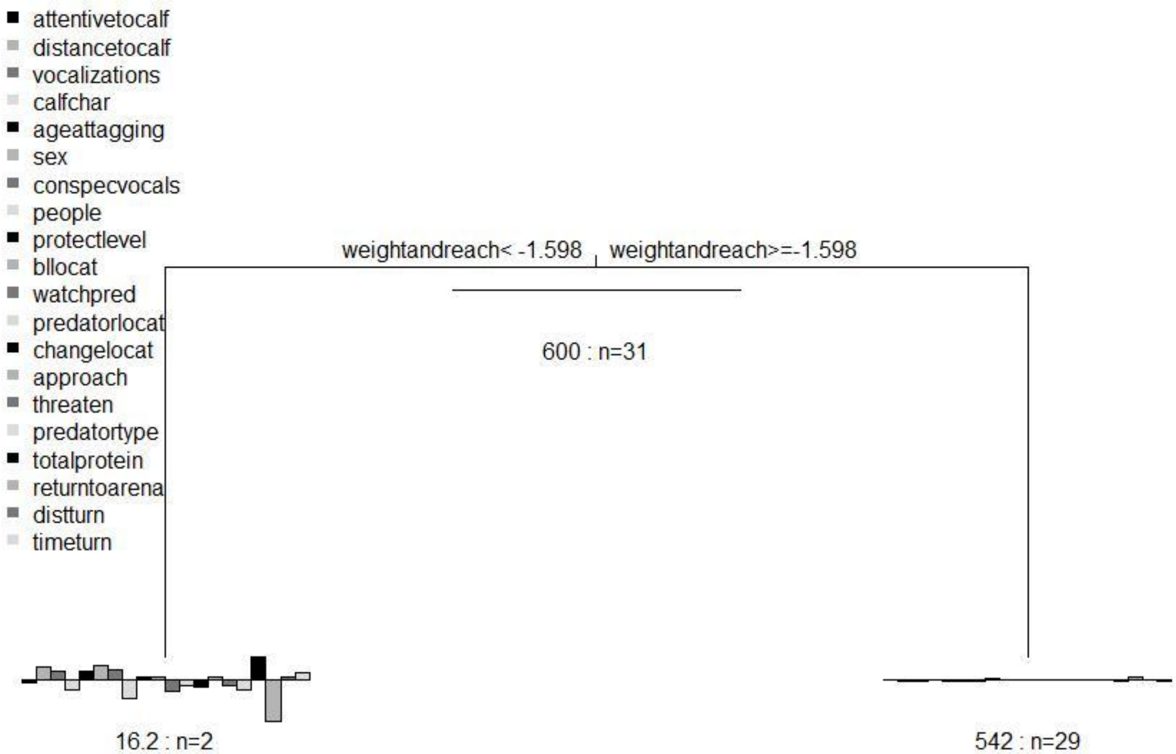

Figure A3 Diagram of a multiple regression tree predicting variations in maternal behaviour from variations in pre-breeding temperament of replacement heifers. Barplots show the standardized multivariate maternal behaviour means at each node. The cyclical shading (black, grey, dark grey, light grey) indicate the maternal behaviour variables and run from left to right on the barplots. This tree explains 10.4% of the variance in the maternal behaviour. Euclidean distances were used for splitting. The depth of the tree following each split is proportional to the variance explained for each split.

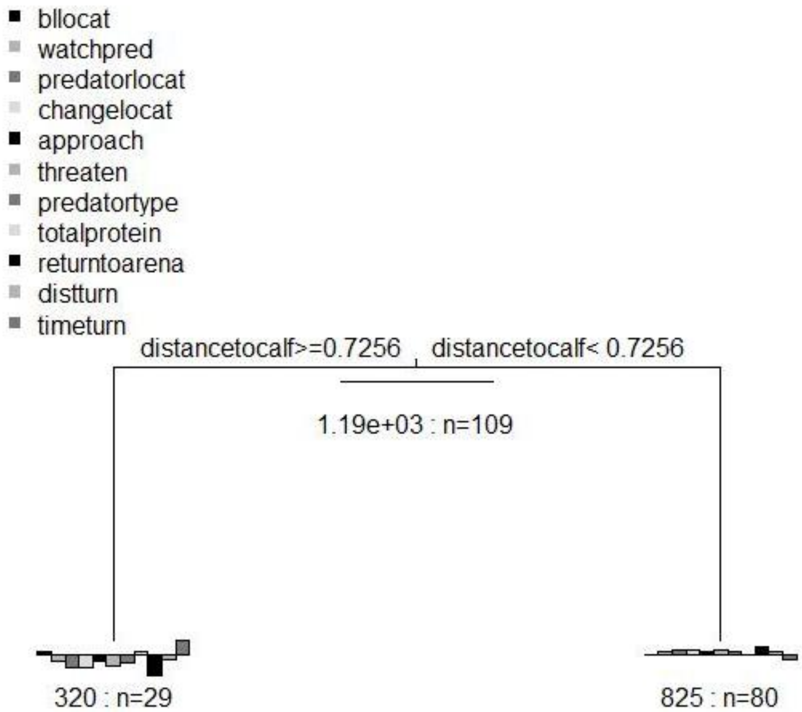

Figure A4 Diagram of a multiple regression tree for year 2 predicting variations in a cow's response to a predator from variations in her response to a stockperson handling her calf. Barplots show the standardized multivariate predator response means at each node. The cyclical shading (black, grey, dark grey, light grey) indicate the predator response variables and run from left to right on the barplots. This tree explains 9.1% of the variance in the maternal behaviour. Euclidean distances were used for splitting. The depth of the tree following each split is proportional to the variance explained for each split.

APPENDIX B

Survey of Beef Cattle Producers

Please place an 'x' in the appropriate box(es), unless otherwise specified.

<u>2009 Calving Season</u>

1. How many first calf heifers did you calve out last calving season?

______________________ (#)

2. How many mature cows did you calve out last calving season?

______________________ (#)

3. What time of year did you calve?

Start Date: __________________

End Date: __________________

4. Where did you calve out your mature **cows**?

☐ Pasture ☐ Corral/ barn ☐ Other (please specify)____________

5. Where did you calve out your first-calf **heifers**?

☐ Pasture ☐ Corral/ barn ☐ Other (please specify)___________

6. What procedures are performed on your calves within the first **2 days** of age? (mark all that apply)

- ☐ Tagged
- ☐ Weighed
- ☐ Males are castrated
- ☐ Cow and calf are moved to a different pen or pasture
- ☐ Dehorned
- ☐ Injections
- ☐ Minimal contact (i.e. check sex of calf)
- ☐ No contact
- ☐ Other: (please specify) ___________________

7. How many females in your herd during the **last calving season** do you estimate would try to hurt you (or did), if given the chance, if you were to handle their newborn calf?

_________________ (# of females)

(If zero**,** proceed to question 8)

a. Estimate the number of these potentially dangerous females in your herd in each age category.

____ 1st Calf Heifers ____ Mature cows

b. How many of these cows/heifers did you, or will you cull this year because they were dangerous at calving?

_______________________ (# of females)

---

8. How many females in your herd during the **last calving season** mis-mothered their calf?

_________________ (# of females)

(If zero, proceed to question 9)

a. Estimate the number of females in your herd that mis-mothered their calves in each age category.

___ 1st Calf Heifers ____ Mature cows

b. Of these cows/heifers, how many have you culled or are you planning to cull this year because they mis-mothered their calf?

_______________________ (# of females)

<u>From your experience:</u>

9. From your experience, do females that are **dangerous** at calving: (select most accurate)

☐ Become **less** dangerous in subsequent calvings
☐ Become **more** dangerous in subsequent calvings
☐ Do not change over time
☐ I don't give them a second chance
☐ Don't know

10. In the month before calving, are **dangerous** mothers: (select most accurate)

- ☐ More docile than the majority of the herd
- ☐ More nervous than the majority of the herd
- ☐ Not noticeably different
- ☐ Other (please specify) ________________________________
- ☐ Don't know

11. <u>Select the 3 most important reasons</u> that females are **dangerous** at calving:

___ C-section or hard pull
___ Breed characteristics
___ Hormones present at calving
___ Interruption by another cow or person
___ Old cow
___ Weak calf
___ Family line
___ 1st calf heifer
___ Other (please specify) ________________________________

---

12. From your experience, do females that **mis-mother** their calves: (select most accurate)

- ☐ Mis-mother **more** often in subsequent calvings
- ☐ Mis-mother **less** often in subsequent calvings
- ☐ Do not change over time
- ☐ I don't give them a second chance
- ☐ Don't know

13. In the month before calving, are females that **mis-mother** their calf: (select most accurate)

- ☐ More docile than the majority of the herd
- ☐ More nervous than the majority of the herd
- ☐ Not noticeably different
- ☐ Other (please specify) ______________________________________
- ☐ Don't know

14. Select the 3 most important reasons that females **mis-mother** their calves:

___ C-section or hard pull
___ Breed characteristics
___ General lack of interest by the mother
___ Interruption by another cow or person
___ Twins
___ Weak calf
___ Family line
___ 1st calf heifer
___ Other (please specify) ________________________________

---

15. What is the level of production you would require to keep a cow/ heifer that was dangerous at calving, assuming there is no other reason to cull her: (select the minimum performance level to keep the cow).

- ☐ Would keep the cow regardless of performance
- ☐ Would keep her as long as she raised a calf
- ☐ Would keep her if she raised an average or better calf
- ☐ Would keep her only if she raised an above average calf
- ☐ Would cull the cow regardless of performance
- ☐ Would only cull the cow if she did it more than one year

16. What is the level of production you would require to keep a cow/heifer that mis-mothered her calf at calving, assuming there is no other reason to cull her: (select the minimum performance level to keep the cow).

- ☐ Would keep the cow regardless of performance
- ☐ Would keep her as long as she raised a calf
- ☐ Would keep her if she raised an average or better calf
- ☐ Would keep her only if she raised an above average calf
- ☐ Would cull the cow regardless of performance
- ☐ Would only cull the cow if she did it more than one year

---

17. Have you ever been intentionally hurt by a cow/heifer with a newborn calf?

☐ Yes ☐ No (If no, proceed to question 18)

➢ **If yes**, did you see a doctor for the injury?

☐ Yes ☐ No

➢ **If you were hurt**, did you cull the cow/heifer for that reason?

☐ Yes

---

18. In the past **5 years** have you had any problems in your herd with predators killing calves?

☐ Yes ☐ No (if no, proceed to question 19)

- **If yes**, how many calves did you lose over the 5 year period?

  ____

- **List** all the predators that you know or believe are responsible:

---

19. Are you:

☐ Male ☐ Female

20. Please select your age category

☐ 35 or younger
☐ 36-45
☐ 46-55
☐ 56-65
☐ Over 65

21. How many years have you been involved in the cattle industry?

22. Do you raise:

☐ Purebred cattle ☐ Commercial cattle ☐ Both

23. What breed(s) of cattle do you have? (if crossbred, please list all breeds)

24. Other comments?

APPENDIX C

Survey Results

Table C1 Incidence of dangerous cattle

	% of herd	Number of dangerous cattle	% of heifers	Number of dangerous 1st calf heifers	% of Cows	Number of dangerous cows	% of dangerous culled	Number culled
Average/herd	4.3	11.5	2.8	1.3	4.7	9.8	38.6	2.0

Table C2 Incidence of mis-mothers

	% of herd mis-mothers	Number of mis-mothers	% of heifers	Mis-mothering 1st calf heifers	% of cows mis-mother	Mis-mothering cows	% of mis-mothers culled	Mis-mothers culled
Average/ herd	1.0	2.9	3.2	1.6	0.6	1.2	51.9	3.2

Table C3 Changes seen in subsequent parities from cattle that are dangerous after calving or mis-mother their calf

	Dangerous Cattle	% of responses	Mis-mothers	% of responses
Don't know	6	3.8	18	11.0
Don't give a 2nd chance	32	20.4	62	37.8
No change	56	35.7	25	15.2
More	34	21.7	12	7.3
Less	29	18.5	47	28.7

Table C4 Temperament differences in the month before calving in cattle that are dangerous after calving or mis-mother their calf

	Dangerous Cattle	% of responses	Mis-mothers	% of responses
Don't know	11	6.7	24	14.3
Other differences	3	1.8	2	1.2
No noticeable differences	104	63.4	123	73.2
More nervous	41	25.0	13	7.7
More docile	5	3.0	6	3.6